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TEST REPORT FOR
JET PROPULSION LABORATORY
TOROIDAL TRANSFORMERS
PROCEDURE 902.66-01

SUBMITTED BY

VARO, INCORPORATED
ENVIRONMENTAL LABORATORY

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, pursuant to a subcontract issued under Prime Contract NAS7-100 between the California Institute of Technology and the United States of America represented by the National Aeronautics and Space Administration.

FINAL REPORT

ON

Test Program

902.66-01

to

JET PROPULSION LABORATORY

December 24, 1965

by

AUTHORS: John H. McLin

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on

CONTRACT NUMBER 950989

JOB NUMBER 06391

APPROVED BY

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ABSTRACT

This report contains the results of transformer Qualification tests performed in accordance with J.P.L. Test Procedure 902.66-01, Electronic Component Parts Reliability, Power Transformers, dated 12 June 1964.

Two types of transformers were tested concurrently. Twelve units of each type were supplied by each of four vendors. One type, Part #D3172671, was an encapsulated multi-secondary toroidal transformer and the other, Part #D3172922, an open-construction ratio toroidal transformer. Vendors supplying the transformers were:

Magnetic Circuit Elements, Inc. (MCE)

Robert M. Hadley Co. (RMH)

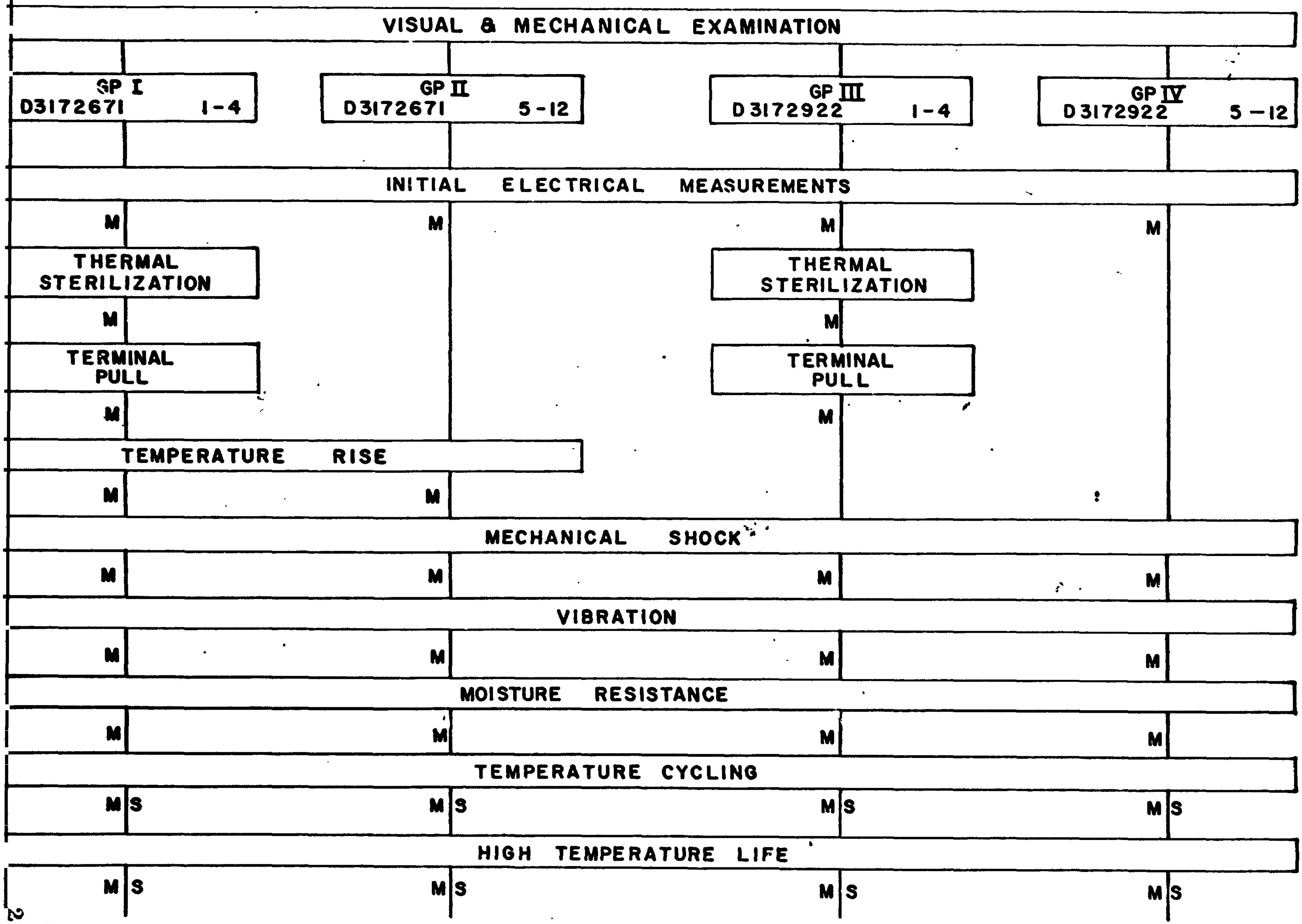
D. B. Products (DBP)

Coast Coil (CC)

The transformers from each vendor were serialized 1 - 12 and categorized into one of two groups. A flow chart has been prepared and made a part of this abstract to show grouping and qualification test sequence. For Part #D3172671, Unit serial numbers 001 through 004 were assigned to Group I and unit serial numbers 005 through 012 were assigned to Group II. For Part #D3172922, Unit serial numbers 001 through 004 were assigned to Group III and unit serial numbers 005 through 012 were assigned to Group IV. The change in group numbering (i.e. Groups I, II, III, and IV, rather than Groups I and II for each part type) was requested by the data processing center, C.E.I.R., because of the differences in part design, number of tests involved, page and line headings of the computed statistics sheets.

FIG 4

FLOW CHART



M= ·· 'A POINT MEASUREMENT

The following paragraphs list each test in flow chart sequence and important results, including catastrophic failures.

Visual and Mechanical Examination

Part #D3172671

MCE Of the 36 dimensions measured (3 per unit) 35 dimensions were out of tolerance.

RMH Of the 36 dimensions measured (3 per unit) 30 dimensions were out of tolerance. The method used in bringing leads out of the case was not in accordance with the specification.

DBP Of the 36 dimensions measured (3 per unit) 20 dimensions were out of tolerance.

CC Of the 36 dimensions measured (3 per unit) 12 dimensions were out of tolerance (Leads).

Part #D3172922

MCE Of the 36 dimensions measured (3 per unit) 24 dimensions were out of tolerance.

RMH Of the 36 dimensions measured (3 per unit) 12 dimensions were out of tolerance (Leads).

DBP Of the 36 dimensions measured (3 per unit) 24 dimensions were out of tolerance.

CC Of the 36 dimensions measured (3 per unit) 12 dimensions were out of tolerance (Leads).

Initial Electrical Tests

Initial electrical tests were performed in the following order:

D. C. Resistance of each winding

Excitation Current

Turns Ratio

Center-tap Unbalance

Insulation Resistance (500 VDC)

Dielectric Withstanding Voltage (500 VRMS, 60 cps)

PART #D3172671

MCE The D. C. Resistance of all windings, all units, was below the specified lower limit. Excitation Current could not be measured using the specified input, 30 VRMS, 2400 cps, because of insufficient turns and/or core properties. By increasing frequency of the source E.M.F. to 6000 cps, distortion was decreased to an acceptable level, and measured excitation current was reduced to values less than the 90 milliampere maximum limit. The J.P.L. cognizant engineer decided to allow this vendor's part to remain in the test program with the provision that a source E.M.F. frequency of 6000 cps be used in all future Excitation Current and other tests, such as Temperature Rise. In comparison with samples supplied by the other three vendors, MCE samples should have been classified as catastrophic failures. Turns Ratio, Center-tap Unbalance, Insulation Resistance and Dielectric Withstanding Voltage tests were satisfactory, all units.

RMH All tests were satisfactory.

DBP An open winding was discovered in one unit during D. C. Resistance measurements. The faulty unit was classified catastrophic. The D. C.

Resistance of two windings (#3 and #8) of all units measured less than the specified lower limit. One or more windings of three units were out of tolerance when tested for Turns Ratio. All other tests were satisfactory.

CC All tests were satisfactory.

Part #D3172922

MCE The secondary winding D. C. Resistance of five units was below the lower limit. All other tests were satisfactory.

RMH The secondary winding D. C. Resistance of three units was below the lower limit. All other tests were satisfactory.

DBP The primary winding D. C. Resistance of three units was greater than the upper limit. Turns Ratio measurements of one unit were out of tolerance. One unit failed Insulation Resistance and was classified catastrophic. All other tests were satisfactory.

CC All tests were satisfactory.

Thermal Sterilization

Part #D3172671, Group I

MCE There was no visible evidence of physical damage and no significant change in electrical characteristics.

RMH There was no visible evidence of physical damage and no significant changes in electrical characteristics.

DBP The cases of all four units were severely discolored and warped. Deep cracks appeared in the potting surfaces. There were no significant changes in electrical characteristics.

CC There was no visible evidence of physical damage and no significant changes in electrical characteristics.

Part #D3172922, Group III

There was no visible evidence of physical damages and no significant changes in electrical characteristics, all parts, all vendors.

Terminal Pull

Part #D3172671, Group I and Part #D3172922, Group III

There was no visible evidence of physical damage, and no significant changes in electrical characteristics, all parts, all vendors.

Temperature Rise

Part #D3172671 Only

DBP Five units exceeded the allowable temperature rise of 35 degrees C. Cases of several units were warped. Cases and potting surfaces of all units were discolored. There were no significant changes in electrical characteristics after Temperature Rise.

Parts supplied by the other three vendors, MCE, RMH and CC were satisfactory.

Mechanical Shock

Part #D3172671

There was no visible evidence of physical damage and no significant changes in electrical measurements, all parts, all vendors.

Part #D3172922

DBP One unit failed the Insulation Resistance test and was classified as a catastrophic failure.

Visual inspection and electrical testing of units supplied by the other three vendors was satisfactory.

Vibration

Part #D3172671

MCE One unit failed excitation current and became a catastrophic failure. Cause of failure was an internal short between the two primary windings. There was no visible evidence of physical damage.

RMH The excitation current of one unit rose above the maximum limit. (The same unit measured high in all remaining tests). There was no visible evidence of physical damage.

DBP There was no visible evidence of physical damage and no significant changes in electrical test results.

CC Excitation current of two units from Group I and one unit from Group II was above the maximum limit after Vibration. (Excitation Current of the same 3 units remained either high or marginal during the remaining tests). There was no visible evidence of physical damage.

Part #D3172922

DBP Insulation Resistance failure caused one unit to be classified as catastrophic during tests after vibration.

Parts supplied by the other three vendors showed no evidence of physical damage nor significant changes in electrical measurements.

Moisture Resistance (MIL-STD-202C, Method 106)

Part #D3172671

DBP One unit (Gp. I) failed Insulation Resistance test after Moisture and was classified catastrophic.

Units supplied by the other three vendors passed the test satisfactorily.

Part #D3172922

MCE There was no visible evidence of physical damage nor significant changes in electrical measurements.

RMH Two units grom Group IV were classified catastrophic failures after Moisture Resistance. One unit had an open winding, the other failed the Insulation Resistance test.

DBP Two units from Group IV failed the Insulation Resistance Test after moisture.

CC There was no visible evidence of physical damage nor significant changes in electrical measurements.

Temperature Cycling

Part #D3172671

There was no visible evidence of physical damage nor significant changes in electrical measurements, all parts, all vendors.

Part #D3172922

MCE All tests were satisfactory

RMH Three units, Group III, failed Insulation Resistance tests and were classified as catastrophic failures.

DBP One unit failed Insulation Resistance tests and was classified as a catastrophic failure.

CC All tests were satisfactory.

Life (2000 Hour)

Electrical tests were performed at 168, 500, 1000, 1500 and 2000 hour intervals.

Part #D3172671

DBP One unit failed D. C. Resistance during electrical tests at the 1000 hour interval because of an open winding and was classified catastrophic.

Parts supplied by the other three vendors passed all tests satisfactorily.

Part #D3172922

There was no evidence of physical damage nor significant changes in electrical measurements, all parts, all vendors.

SUMMARY

Part #D3172671

Coast Coil transformers proved to be the most reliable and were superior, electrically and mechanically, to those produced by the other three vendors. Assuming that all vendors were furnished identical specifications/requirements, transformers supplied by Magnetic Circuit Elements and Robert M. Hadley failed to meet requirements contained in J.P.L. Specification 902.66-01. M.C.E. failed electrical characteristics and RMH failed mechanically because of lead configuration. Case and potting materials used by D. B. Products were damaged by high temperatures. Appearance and poor uniformity in electrical characteristics indicate laxity in quality control.

Part #D3172922

Parts supplied by Coast Coil were superior, electrically and mechanically, to products furnished by the other three vendors. The quality or quantity of insulating tape used by Robert M. Hadley and D. B. Products was responsible for the majority of catastrophic failures among the samples supplied.

There were no catastrophic failures among samples supplied by Magnetic Circuit Elements, Inc.; however, these (MCE) parts had the highest average of out of tolerance failures.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

LIST OF FIGURES

TABLES

APPENDIX

1.0 Introduction

1.1 Purpose

This document is a final report of Qualification test results. Two types of toroidal transformers were subjected to electrical, environmental and life tests specified in Jet Propulsion Laboratory Test Procedure 902.66-01. This test program was started during the month of March, 1965 and completed during the month of November, 1965.

1.2 Contract Information

The contract for this test program was initially made with Dresser HST, a Division of Dresser Industries. Effective July 1, 1965, all HST facilities became the property of Varo, Incorporated. The Magnetics Division of Varo, Incorporated assumed responsibility for operation of the Environmental Laboratory and for completion of the J.P.L. Qualification Test Programs then in progress.

1.3 Test Procedures, Deviations

J.P.L. Test Procedure, 902.66-01, "Electronic Component Parts Reliability, Transformers, Power" was the basic specification governing the qualification test. Deviations to 902.66-01 were authorized by J.P.L. Technical Direction Memorandum #1, dated September 8, 1965.

1.4 Report Format

The format and organization of this report is in accordance with J.P.L. Specification ZPP-2098-GEN. Computation and submittal of component-test statistics were in accordance with J.P.L. Specification ZPP-2040-GEN A. Raw data was recorded manually on J.P.L. Form 1494 and submitted to C.E.I.R., Beverly Hills, California for processing, editing and analysis.

1.5 Consultants

Dr. David R. Cecil, Assistant Professor of Mathematics, North Texas State University, was utilized as a consultant to assist with reliability estimates and comparisons contained in paragraph 4, "Test Results". A copy of the consultant's report is appended.

2.0 Description of Test Items

The ninety-six transformers involved in this test program were procured from four different vendors, namely Magnetic Circuit Elements, Inc., Robert M. Hadley Co., D. B. Products, and Coast Coil. Each vendor was required to furnish twelve (12) units designed and manufactured as specified on J.P.L. Drawing D3172671 and twelve (12) units as specified on J.P.L. Drawing D3172922.

2.1 Part Number D3172671

This transformer is an encapsulated, multi-secondary, toroidal power transformer. It is designed to operate with an input of 30 volts, RMS, 2400 cps. Total volt/ampere rating is approximately 179 VA. The unit has two primary windings, normally connected in parallel to the power source and eight center-tapped, secondary windings, with the center taps of windings 3 and 4, 5 and 6, 7 and 8 commoned in pairs. The transformer windings are terminated in insulated flexible color-coded wire leads approximately 12 inches long. The leads of the samples furnished by the Robert M. Hadley Company were spaced at uniform intervals around the periphery of the unit. The leads of samples from the other three vendors were grouped in one location. The physical characteristics and general dimensions are shown in Figure 1. The schematic and winding identification are shown in Figure 3. The electrical parameters measured, nominal values and tolerances are as listed in Table I.

2.2 Part Number D3172922

This unit is an open-construction ratio toroidal transformer with one center-tapped **primary** winding and one center-tapped secondary winding. It is designed for an input of 24 volts, RMS, 2400 cps. No secondary load currents were specified. The transformer windings are terminated in color-coded, insulated flexible wire leads, approximately 10 inches long. The physical characteristics and general dimensions are as shown in Figure 2. The schematic and winding identification are as shown in Figure 3. The electrical parameters that were measured, nominal values and tolerances are as listed in Table I.

3.0 Description of Test Program

3.1 Test Design

The transformers from each vendor were serialized from 1 to 12 and categorized into one of four groups. The Flow Chart, Figure 4, describes the testing sequence for each group and designates the serial numbers of the components assigned to each group. Data measurement points are identified with the letter "M" and each computed statistics sheet (CSS) submittal point with the letter "S". Two batches of computed statistics sheets in book form were received from C.E.I.R. The first batch contained statistical data resulting from all tests prior to the Life Test. The second batch contained all data from the first batch plus data recorded during and after the Life Test.

3.2 Measurement Procedures

3.2.1 Visual and Mechanical Examination

3.2.1.1 Instruments Used

Calipers, Helios, Serial No. 112

3.2.1.2 Procedure

The dimensions shown in Figures 1 and 2 were measured and recorded. Each specimen was visually examined for quality of workmanship, material, and legibility and permanence of markings, if any.

3.2.2 D. C. Resistance

3.2.2.1 Instruments Used

Digital Voltmeter, Cimron, Model 7200A, Accuracy 0.01% of reading

D. C. Preamplifier, Cimron, Model 6802A, Combined Accuracy of 0.02% FS

Ohms-D.C. Converter, Cimron, Model 6911A, Combined Accuracy 0.05%

3.2.2.2 Procedure

The Digital Voltmeter, in combination with the Ohms-D.C. Converter, was used to measure D. C. Resistance of Part No. D3172922. A four wire system is used with this combination. The unique clips furnished with the equipment were attached to the winding leads and resistance in ohms appeared on the five digit face. The 1000 ohm scale was used permitting measurements from 0.01 to 999.99 ohms.

The windings of Part No. D3172671 were relatively low in resistance and required a change in the procedure just described. The D. C. Preamplifier was combined with the voltmeter, and the Ohms-D.C. Converter was used as a constant current source. Resistance of windings was determined by sending a known current (e.g. 10 ma) through the unknown resistance and measuring the resulting voltage drop with the Voltmeter Preamp combination. The figures appearing on the voltmeter were then read directly in Ohms. The combination of equipment just described permitted accurate measurements of resistance from .0001 to 9.999 ohms. The readings were rounded off to four significant figures and a decimal point to satisfy data processing requirements.

3.2.3 Excitation Current

3.2.3.1 Instruments Used

Digital Voltmeter, Cimron, Model 7200A

AC-DC Converter, Cimron, Model 6701A, Accuracy 0.05% (when combined with Digital Voltmeter above)

Signal Generator, Hewlett Packard, Model 205AG

Resistor, 100 Ohm Standard

Flip Switch Box (See Figure 5)

Frequency Counter, Beckman, Model 7150B

Oscilloscope, Tektronix, Model 545

Amplifier, McIntosh Model MI-200

3.2.3.2 Procedure

The equipment listed above was connected to the proper flip-switch box binding posts as shown in Figure 5. The E_L - E_R Switch was moved to the E_L position and the voltage across the windings under test was adjusted to 30V RMS, 2400 cps for Part No. D3172671. The input voltage used for Part No. D3172922 was 24 V RMS, 2400 cps. The E_L - E_R switch was then moved to E_R position and the voltage shown on the Voltmeter was recorded. By inspection, the decimal point was moved an appropriate number of places to convert the reading to milliamperes.

3.2.3.2 (Continued)

During the Initial Electrical Tests, it was discovered that Magnetic Circuit Elements Part No. D3172671 saturated at approximately 15 V RMS causing severe distortion. By increasing the frequency of the input EMF to approximately 6KC, distortion became negligible and excitation current decreased below the 90ma maximum limit. The cognizant J.P.L. Engineer was advised of this problem, and after due consideration, instructions were issued to change the frequency of the source EMF to 6 KC for this (MCE) particular vendor's part.

3.2.4 <u>Turns Ratio</u>

3.2.4.1 <u>Instruments Used</u>

Signal Generator, Hewlett Packard, Model 205AG

VTVM, (2 ea), Hewlett Packard, Model 400H

Gertsch Ratiotran, Model RT-4

3.2.4.2 <u>Procedure</u>

The instruments listed above and the units under test were interconnected as shown in Figure 6. For Part No. D3172671, Winding #6 was used as the "reference" winding. For Part No. D3172922, the primary winding was used as reference. The source E.M.F. was increased to 10V RMS, 1 KC and the Gertsch decade controls adjusted for minimum on the null indicating meter.

3.2.4.2 (Continued)

Recorded raw data values for Part No. D3172671 were read directly from the Gertsch. For Part No. D3172922 the reciprocal values of the Gertsch readings were calculated and recorded.

3.2.5 Center-tap Unbalance

3.2.5.1 Instruments Used

Same equipment used during Turns Ratio Measurements.

3.2.5.2 Procedure

Measurements required to calculate CT Unbalance were made during the Turns Ratio Test. The test lead connected to the high side of the winding under test (See Figure 6) was moved to the center-tap lead, and the Gertsch decade controls readjusted for a second null. CT Unbalance was calculated using the following formula:

$$\frac{N_1 - N_2}{N_1} \times 100 = \% \text{ Unbalance}$$

Where: N_1 = Difference between Turns Ratio of full winding and turns ratio of CT to low side of winding.

N_2 = Turns Ratio of CT to low side of winding.

3.2.6 Insulation Resistance

3.2.6.1 Instruments Used

Megohmeter, Industrial Instruments, Model L-7, Serial #0194.

3.2.6.2 Procedure

The megohmeter was adjusted to provide a 500V DC test potential. After thirty minutes warm-up, insulation resistance of each transformer was tested in two steps as follows:

Step 1. The transformer under test was placed in a container and covered with #7 lead shot. The 500V DC potential was applied for one minute between a common electrical connection of all transformer leads and an electrode extending from the mass of shot.

Step 2. The 500V DC potential was applied for one minute between a common electrical connection of the leads of the primary winding(s) and a similar connection of the leads of the secondary windings (s).

3.2.7 Dielectric Withstanding Voltage

3.2.7.1 Instruments Used

Dielectric Withstanding Voltage Test Set, Associated Research, Inc., Model 412, Serial #0182.

3.2.7.2 Procedure

Each transformer was tested in two steps as previously described in the Insulation Resistance test paragraph: The applied test potential was 500V RMS, 60 cps. Prior to test, the test instrument was adjusted to indicate leakage currents equal to or greater than one milliampere.

3.3 Environmental Test Procedures

3.3.1 Thermal Sterilization

3.3.1.1 Equipment Used

Temperature Chamber, Conrad, Model FB-32-3-3, Serial #7670 ($\pm 5^{\circ}$ from set)

Pyrometer, Gray Instruments, Model E3067, Serial #0813

3.3.1.2 Procedure

Unit serial numbers one through four of all component codes were placed in the temperature chamber. Two copper-constantan thermocouple junctions were attached to the largest centrally located thermal mass of the grouped transformers. The thermocouple leads were routed through a side port for connection to the pyrometer. The units were then subjected to three Thermal Sterilization Cycles, each cycle consisting of thirty-six hours at $143.5^{\circ}C$. This was determined by frequent measurements with the pyrometer during the first two hours of exposure.

3.3.2 Terminal Pull

3.3.2.1 Equipment Used

Five Pound Healthways Weight

3.3.2.2 Procedure

The specimen under test was clamped in a vise and positioned to allow the leads to hang freely over the edge of a bench. A five pound weight was attached with a surgeon's hemostat to each lead in turn for a period of at least 10 seconds.

3.3.3 Temperature Rise (D3172671 Only)

3.3.3.1 Equipment Used

Oven, Gruenberg Electric Co., Model TRO

Pyrometer, Gray Instruments, Model E-3067

Digital Voltmeter, Cimron, Model 7200A

AC-DC Converter, Cimron, Model 6701A

Ohms-DC Preamplifier, Cimron, Model 6911A

DC Preamplifier, Cimron, Model 6802A

Generator, CML, Model 1435D

VTVM, Hewlett Packard, Model 400H

Power Transformer, Step-Down, BACTH20AA277

3.3.3.2 Procedure

The transformers were connected to the load fixture and power source as shown in Figure 7 and placed in the oven still-air chamber. The junction of a copper-constantan thermocouple lead was positioned at the same level and six inches distant from the test specimens. Oven controls were then adjusted to obtain a still-air temperature of 90°C as measured with the pyrometer. The units were allowed to remain at this temperature for at least eight hours before the D. C. Resistance of winding #6 was

3.3.3.2 (Continued)

measured and recorded. The load fixture was designed to permit disconnecting Winding #6 from its resistive load and rapid re-connection to the Cimron constant current source. Two additional wires were connected directly to Winding #6 to serve as voltage sensing leads. D. C. Resistance was measured as previously described in paragraph 3.2.2 and recorded. Temperature (t) was also measured and recorded. The CML Generator was then adjusted for a reading of 30V RMS, 2400 cps across the transformer primary windings. Units manufactured by Magnetic Circuit Elements were tested using an input of 30V RMS, 6000 cps. Specified secondary currents were obtained by varying load rheostats and observing the accompanying voltage drop across the associated 1 ohm resistor. (e.g. 0.44 volts = 0.44 amperes). Load currents were readjusted hourly to compensate for current reduction caused by heating the load resistor. Still-air temperature was measured periodically to determine the extent of temperature increase caused by the transformers. After eight hours, the unit was deenergized and the D. C. Resistance of winding #6 was measured. Resistance (R) was remeasured 30 minutes later to insure temperature stabilization.

Temperature rise was calculated using the following formula:

$$\Delta T = \frac{R - r}{r} (t + 234.5) - (T - t)$$

Where:

ΔT = Temperature rise in degrees centigrade above specified maximum ambient temperature.

3.3.3.2 (Continued)

R = Resistance of winding in ohms at temperature (T + _ T)

r = Resistance of winding at temperature (t)

t = Specified initial ambient temperature in degrees centigrade

T = Maximum ambient temperature in degrees centigrade

3.3.4 Mechanical Shock

3.3.4.1 Equipment Used

Shock Machine, AVCO, Type SM-020, Model 1

Contact Chatter Monitor, Coplan, Model CCM-1A

Oscilloscope, Tektronix, Model 545

Cathode Follower, Columbia, Model 4000R

Accelerometer, Endevco, Model 2213

Scope Camera, Dumont, Type 302

3.3.4.2 Procedure

The transformers were mounted to an aluminum fixture designed to accept 16 each part #D3172671 and 16 each #D3172922. Leads of each winding were connected to form a series circuit, terminated at the proper connections of the Contact Chatter Monitor. Prior to starting the required series of shocks, drop height and resulting pulse shapes were determined by loading the machine elevator with ballast (approximating weight of the test specimens and fixtures) and photographing scope pulses generated by the accelerometer at various drop heights. After reaching the

3.3.4.2 (Continued)

desired pulse height and width, ballast was replaced with the specimen laden test fixtures. The specimens were then subjected to 5 shocks in both directions along each of the three mutually perpendicular planes. Shock amplitude was 300 G's, sawtooth, with three millisecond pulse duration. The chatter monitor was monitored for discontinuities equal or greater than 0.1 millisecond during and after each shock. The oscilloscope was observed during one of each series of five shocks to assure occurrence of the required shock pattern.

3.3.5 Vibration

3.3.5.1 Equipment Used

Exciter, M.B., Model C-25H

Console, M.B., Model N572

Amplifier, M.B., Model T666

Accelerometer, Endevco, Model 2213

Dyna-Monitor, Endevco, Model 2702

Chatter Monitor, Coplan, Model CCM-1A

Preamplifier, Endevco, Model 2616

3.3.5.2 Procedure

Test specimens were mounted on the vibration test fixture and subjected to vibrations in accordance with the amplitudes and time periods shown in Figure 9. "G" level and displacement were

3.3.5.2 (Continued)

determined by signal returns from a velocity coil during the 20 to 37 cycle range. An accelerometer mounted on the fixture with the specimens was utilized for control during the remaining portion of the cycle, 27 to 3000 cps. Prior to the start of the vibration test, windings of specimens were wired in series and connected to the chatter monitor which was adjusted to detect discontinuities equal to or greater than 0.1 millisecond.

3.3.6 Moisture Resistance

3.3.6.1 Equipment Used

Temperature Chamber, Conrad, Model CB8-2-2

Temperature Humidity Chamber, Conrad, Model FD-36-3

Amplifier, M.B., Model T666

Console, M.B., Model N-572

Exciter, M.B., Model C25H

3.3.6.2 Procedure

The test specimens were mounted on vibration fixtures and subjected to ten temperature-humidity cycles in accordance with Method 106-1, MIL-STD-202C (See Figure 10). There was no polarizing voltage applied. During five of the first nine cycles, the units were removed from the humidity chamber and placed in a separate temperature chamber which had been stabilized at -10°C (Step 7a). After three hours in the cold chamber the units were

3.3.6.2 (Continued)

vibrated for fifteen minutes, using a simple harmonic motion having an amplitude of 0.03 inch (0.06 total excursion), the frequency being varied uniformly between 10 and 55 cps. The entire frequency range, from 10 to 55 cps and return to 10 cps was traversed in approximately one minute (Step 7b).

3.3.7 Temperature Cycling

3.3.7.1 Equipment Used

Conrad Temperature Chamber, Model FB-32-3-3, Serial #7669

Conrad Temperature Chamber, Model FB-32-3-3, Serial #7670

3.3.7.2 Procedure

The unenergized specimens of both part types were subjected to five cycles of extreme temperature conditions--one cycle consisting of:

Thirty Minutes at -65°C

Fifteen Minutes at 25°C

Thirty Minutes at 125°C

Fifteen Minutes at 25°C

Two chambers stabilized at the specified temperatures were utilized for this test, and temperatures were monitored continuously. Following completion of the fifth cycle, the specimens were removed from the temperature chamber and allowed to stabilize at room ambient for eight hours.

3.4 Life Test Procedure

3.4.1 Equipment Used

Oven, Blue M. Electric, Model POM 5886C, Serial #PA404

Oven, Blue M. Electric, Model POM 5886C, Serial #PA414

3.4.2 Procedure

3.4.2.1 Prior to the Life Test the specimens were inspected for proper identification and divided into five test groups as follows:

1) Part Type 3172922, All specimens.
2) Part Type 3172671, D. B. Products
3) Part Type 3172671, Coast Coil
4) Part Type 3172671, R. M. Hadley Co.
5) Part Type 3172671, M.C.E.

3.4.2.2 The non-energized specimens were placed by test group into the ovens stabilized at 130°C and subjected to a Life Test of 2000 Hours. In order to facilitate data point testing the test groups were placed in the ovens on different days (See Figure 8). The oven temperatures were held at 130° $\pm 2^{\circ}$ C and recorded on a Partlow temperature recorder which is an integral part of each oven.

3.4.2.3 Life Test Data Points

At specified intervals during the Life Test i.e. 0 (Post Temperature Cycle Measurements) 168, 500, 1000, 1500 and 2000 hours, (Figure 8) within ± 8 hours, each group was removed

3.4.2.3 (Continued)

from its oven and allowed to stabilize at room ambient temperature under forced air for six hours. Following stabilization at room ambient D. C. Resistance, Excitation Current and Insulation Resistance measurements were performed. After completion of the data point measurements the specimens were returned to the oven.

3.5 Data Recording and Verification Procedure

3.5.1 Test fixtures, equipment, and connections were carefully inspected to insure proper testing. The test equipment calibration was checked periodically against known standards to insure accurate measurements.

3.5.2 Measurements of the various parameters were recorded on J.P.L. Form 1494 and compared with the specified parameter limits and previous measurements to discover erroneous readings or radical variations in measurements.

3.6 Failure Verification and Analysis Procedure

3.6.1 A log was maintained throughout the test to record information pertaining to catastrophic failures and test conditions.

3.6.2 Following a confirmed catastrophic failure, a Failure Report (Figure 11) Form was initiated and completed with information pertinent to the failure.

3.6.3 Each failed specimen was carefully retested to confirm the type of failure and to decide the method of analysis.

3.6.4 D3172922 Analysis

3.6.4.1 Each failed specimen was carefully inspected for external defects which might have caused the failure. If the type of failure indicated an internal defect, the outer insulating tape and wire was carefully removed to determine the cause of failure.

3.6.5 D3172671 Analysis

3.6.5.1 Each failed specimen was visually inspected for external defects which might have contributed to the failure. If an internal defect was indicated the outer case was cut away with a hacksaw and the potting removed with a chisel or electric hand grinder.

3.6.5.2 It was extremely difficult to analyze these specimens due to the hardness of the potting compound and impregnation, number of windings, and lack of assembly information.

3.6.6 After each analysis a Failure Analysis Form (Figure 11) was completed with the mode of failure, cause of failure and failure classification.

4.0 Test Results

4.1 Catastrophic Failures, Part #D3172671

4.1.1 Definition

Tranformers exhibiting an open or shorted condition or insulation resistance measurements of less than 10 megohms were classified as catastrophic failures.

4.1.2 Magnetic Circuit Elements, Inc. (Component Code 001)

4.1.2.1 During initial electrical tests, it was discovered that Excitation Current could not be measured using the specified input voltage and frequency (30V RMS, 2400 cps). Experimentation proved that satisfactory operation could be obtained by increasing the frequency of the source E.M.F. to 6000 cps. The cognizant J.P.L. Engineer was advised of this problem, and after due consideration, decided that this vendor's part would be kept in the Qualification Test program. Excitation Current would be tested using an input of 30V RMS at 6000 cps, with 90 ma established as the maximum. The temperature rise test would also be conducted using the newly specified input. These units could not be compared with transformers submitted by the other three vendors because of dissimilar electrical characteristics.

4.1.2.2 Unit Serial #004 (Group I) failed Excitation Current tests after Vibration. Internal inspection during failure analysis revealed a short circuit between the two primary windings.

4.1.3 Robert M. Hadley, (Component Code 002)

There were no catastrophic failures among the samples supplied by this vendor.

4.1.4 D. B. Products, (Component Code 003)

4.1.4.1 Unit Serial #004 (Group I) failed insulation resistance test between windings 9 and 10. The breakdown occurred between two adjacent leads.

4.1.4.2 Unit Serial #007 (Group II) failed D. C. Resistance measurements during the initial electrical tests. Internal examination revealed a cold solder joint at winding upending and lead wire, winding #4.

4.1.4.3 Unit Serial #012 (Group II) failed D. C. Resistance measurements after 1000 hours of the Life Test. The break in the winding could not be found during failure analysis because of difficulties in removing windings from the core.

4.1.5 Coast Coil, (Component Code 004)

There were no catastrophic failures among samples supplied by this vendor.

4.1.6 Catastrophic Failures, Part #D3172922

4.1.6.1 Magnetic Circuit Elements, Inc., (Component Code 005)

There were no catastrophic failures among samples submitted by this vendor.

4.1.6.2 Robert M. Hadley, (Component Code 006)

4.1.6.2.1 Unit Serial numbers 002, 002, and 004 (Group III) failed insulation resistance tests after Moisture Resistance. Insulation breakdown occurred at the winding upendings and Lead junctions.

4.1.6.2.2 Unit Serial Number 009 (Group IV) failed insulation resistance tests after Moisture Resistance. Insulation breakdown occurred at the winding upendings and Lead junctions.

4.1.6.2.3 Unit Serial Number 012 (Group IV) failed D. C. Resistance measurements after Moisture Resistance. Failure analysis proved that the open in the secondary winding was caused by a point on the wire which had been nicked during the winding process.

4.1.6.3 D. B. Products, (Component Code 007)

Unit Serial numbers 002, 005, 007, 008, 009, 011. Mode of failure was similar for these units. Insulating tape covering lead-up-ending junctions was chafed during handling causing Insulation Resistance failure, windings to "case".

4.1.6.4 Coast Coil, (Component Code 008)

There were no catastrophic failures among the samples supplied by this vendor.

4.2 Parametric (Out of Tolerance) Failures, Part #D3172671

4.2.1 Definitions

4.2.1.1 D. C. Resistance

A parametric failure was declared when measurement of a winding exceeded the specified upper and lower limits during the initial and succeeding electrical test points.

4.2.1.2 Excitation Current

Measured excitation currents exceeding the specified upper and lower limits during initial and succeeding electrical test points is classified as a parametric failure.

4.2.1.3 Turns Ratio

Turns Ratio measurements exceeding the specified upper and lower limits during initial and succeeding electrical test points is classified as a parametric failure.

4.2.1.4 Temperature Rise

Transformers were classified "out of tolerance" failures when the measured temperature rise exceeded 35°C.

4.2.2 Magnetic Circuit Elements, Inc. (Component Code 001)

4.2.2.1 D. C. Resistance

The resistance of all windings of the twelve samples tested measured less than the specified lower limit during initial and most of the succeeding electrical test points.

4.2.2.2 Excitation Current

One unit in Group I and six units in Group II failed excitation current measurements at the 1500 hour Life test point.

4.2.2.3 Turns Ratio

There were no Turns-Ratio failures.

4.2.2.4 Temperature Rise

The temperature rise of the twelve samples remained below 35°C.

4.2.3 Robert M. Hadley.(Component Code 002)

4.2.3.1 D. C. Resistance

The erratic changes in evidence are attributable to measurement techniques and variations in winding temperatures. These failures could not be verified.

4.2.3.2 Excitation Current

Unit Serial #002, Group I. Excitation Current exceeded the upper limit during electrical tests after Vibration.

4.2.3.3 Turns Ratio

There were no turns ratio failures.

4.2.3.4 Temperature Rise

Temperature Rise of the twelve samples remained below 35°C.

4.2.4 D. B. Products, (Component Code 003)

4.2.4.1 D. C. Resistance

Windings #3 and #8 (Primary Windings), all twelve samples, measured less than the lower limit during the initial electrical tests.

4.2.4.2 Excitation Current

There were no failures in excitation current.

4.2.4.3 Turns Ratio

4.2.4.3.1 Group I

Initial Electrical Tests

Unit Serial #002 - Winding 4 measured low.

Unit Serial #003 - Winding 4, 9, and 10 measured high.

Unit Serial #004 - Winding 1 measured low; windings 4, 9 and 10 measured high.

After Moisture Resistance

Unit Serial #004 became a catastrophic failure because of Insulation Resistance and was not tested for Turns Ratio.

Unit Serial #'s 002 and 003 - Turns Ratio Failures found during initial electrical tests were repeated.

4.2.4.3.2 Group II

Failures during Initial Electricals and Electricals after moisture were identical as follows:

Unit Serial #006 - Windings 2 and 4 high

Unit Serial #008 - Winding 5 low

Unit Serial #009 - Winding 1 high

Unit Serial #010 - Winding 2 high

Unit Serial #012 - Winding 1 low; windings 9 and 10 high

4.2.4.4 Temperature Rise

Unit serial numbers 002, 003, 004, 005, 006 exceeded the allowable temperature rise of 35°C.

4.2.5 <u>Coast Coil, (Component Code 004)</u>

4.2.5.1 <u>D. C. Resistance</u>

Failures indicated on the chart were noted during the 1500 hour Life test point and were caused by operator error.

4.2.5.2 <u>Excitation Current</u>

Unit Serial numbers 001 and 002 (Group I). Excitation current exceeded the 90 milliamp maximum during electrical tests after Vibration and remained above or near the maximum limit during subsequent tests.

Unit Serial number 006, Group II. Excitation current exceeded 90 milliamps during tests after Vibration and remained above or near the limit during subsequent tests.

4.2.5.3 <u>Turns Ratio</u>

There were no Turns Ratio failures.

4.2.5.4 <u>Temperature Rise</u>

There were no Temperature Rise Failures.

4.3 **Parameter (Out of Tolerance) Failures, Parts #D3172922**

4.3.1 **Definition**

Failures in D. C. Resistance, Excitation Current and Turns Ratio are as defined in paragraph 4.2.1 of this report. This part was not subjected to Temperature Rise Tests.

4.3.2 **Magnetic Circuit Elements, Inc. (Component Code 005)**

4.3.2.1 **D. C. Resistance**

Unit serial numbers 001, 002 and 004 (Group III) Resistance of the secondary winding was less than the lower limit, all tests. Unit Serial number 003 -- secondary winding resistance was less than lower limit on all tests, with the exception of Initial, after terminal pull and after vibration.

Group IV. D. C. Resistance of the secondary windings, all units with the exception of Serial number 009 were less than the lower limit during one or more of the scheduled test points.

	Serial No.	No. Failures (DCR, Secondary)
Group III	001	12
	002	12
	003	9
	004	12
Group IV	005	6
	006	2
	007	1
	008	10

4.3._ (Continued)

	SERIAL NO.	NO. FAILURES
Group IV	009	0
	010	9
	011	8
	012	8

4.3.2.2 Excitation Current

Unit Serial #009 excitation current rose above the upper limit after Moisture Resistance and Temperature Cycling.

Unit Serial #007 and 010 exceeded upper limits after Temperature Cycling.

Unit Serial #012 exceeded upper limit after 2000 hours Life.

4.3.2.3 Turns Ratio

There were no Turns Ratio failures.

4.3.3 Robert M. Hadley

4.3.3.1 D. C. Resistance

Unit Serial #003, Group III. D. C. Resistance of the primary winding exceeded the upper limit after Terminal Pull.

Unit Serial #004, Group III. D. C. Resistance of the secondary winding fell below the lower limit during Initial, After Thermal Sterilization, After Terminal Pull, After Mechanical Shock and After Vibration.

Unit Serial #005, Group IV. D. C. Resistance of the secondary winding fell below the lower limit, all tests.

Unit Serial #009, Group IV. D. C. Resistance of the secondary winding fell below the lower limit during the first four tests and was then classified as catastrophic.

4.3.3.2 Excitation Current

Unit Serial #003, Group III. High excitation current, Insulation Resistance less than 10 K megohms after Moisture Resistance.

Unit Serial #005, 006, 007, 008, 010, 011 (Group IV). High excitation current after Moisture Resistance. Insulation Resistance measurements were less than 10 K megohms. Units #009 and 012 became catastrophic failures.

4.3.3.3 Turns Ratio

There were no Turns Ratio Failures.

4.3.4 L. L. Products, (Component Code 007)

4.3.4.1 D. C. Resistance

Unit Serial #003, Group III. D. C. Resistance of the primary winding was above the upper limit after Terminal Pull.

Unit Serial #006, Group IV. D. C. Resistance of the primary was above the upper limit during Initial and all subsequent tests.

Unit Serial #005 and 011. D. C. Resistance of the primary was above the upper limit during the Initial test.

Unit Serial #006. D. C. Resistance of the secondary winding was below the lower limit after 168 Hour Life.

4.3.4.2 Excitation Current

There were no Excitation Current failures.

4.3.4.3 Turns Ratio

There were no Turns Ratio failures.

4.3.5 Coast Coil, (Component Code 008)

4.3.5.1 There were no parametric failures during any of the Qualification tests.

4.4 Visual - Mechanical

4.4.1 Part #D3172671

4.4.1.1 Magnetic Circuit Elements, Inc.

Dimension	No. OT
2.620 ±.030 in.	12 (2.565 Typ)
1.250 ±.005 in.	11 (2.241 Typ)
Leads 12.00 in.	12 (14 - 16 Typ)

4.4.1.2 Robert M. Hadley

Dimension	No. OT
2.620 in.	12 (2.570 Typ)
1.250 in.	6
Leads	12 (14.5 - 15.2 Typ)

The method used in bringing leads from the case did not conform with Figure II cf Test Procedure 902.66-01.

4.4.1.3 D. B. Products

Dimension	No. OT
2.620 in.	0
1.250 in	8
Leads	12 (7.5 - 10.5 Typ)

4.4.1.4 Coast Coil

Dimension	No. OT
2.620 in.	0
1.250 in.	0
Leads	12 (14.5 - 16.5 Typ)

4.4.2 Part #D3172922

4.4.2.1 Magnetic Circuit Elements, Inc.

Dimensions	No. OT
1.00 in. Max.	12 (1.25 Typ)
.500 in. Max	2
Leads, 10 in. Typ	12 (11.1 - 11.3 Typ)

4.4.2.2 Robert M. Hadley

Dimensions	No. CT
1.00 in.	0
.500 in.	0
Leads	12 (11.5 - 12.0 Typ)

4.4.2.3 D. B. Products

Dimensions	No. OT
1.00 in.	12 (1.04 Typ)
.500 in.	0
Leads	12 (9.5 - 9.6 Typ)

4.4.2.4 Coast Coil

Dimensions	No. OT
1.00 in.	0
.500 in.	0
Leads	12 (11.0 - 11.5 Typ)

4.4.3 Physical Damage

4.4.3.1 D. B. Products, Part #D3172671

All samples were damaged from exposure to heat, (Thermal Sterilization, Temperature Rise, Life). Damages consisted of warped tubing, cracks in the potting compound and discoloration of all surfaces.

4.4.3.2 All other samples, both part types, were undamaged by exposure to heat.

4.5 Reliability Estimates and Comparisons.

Assuming an exponential failure rate the following tables present the catastrophic and parametric failure rates in percent per 1000 hours at 90%, 60% and 50% confidence levels. A one-sided confidence interval must be used when there are no failures, otherwise a two-sided confidence interval is used. When two-thirds or more of the parts under test failed, no confidence intervals are given since any interval would be very large and quite inaccurate.

To fit the data to an exponential distribution requires that (1) the samples be selected randomly and (2) any sample that fails at any time during the test be removed at the first reading following failure. In other words, we must have random sampling without replacement.

The tests run involve sampling with replacement and therefore estimations of confidence intervals for some of the data cannot be made. Consider the data for Part D3172671, Hadley, parameter 11, group 1. Here is a sample of size 4 with one failure each at 168, 500, 1000, 1500 and 2000 hours. It is assumed here that the same part caused this failure each reading and a two-sided confidence interval is given using one failure in a sample of size 4. Now consider the data for Part D3172671, D. B. Products, parameter 8, group 2. Here is a sample of size 7 (to begin with) having 5 failures at 168 hours, 3 failures at 500 hours, 1 failure at 1000 hours, 4 failures at 1500 hours, and 5 failures at 2000 hours. No confidence interval can possibly be given for this data since some early failures were not failures later;

4.5 (Continued)

there is no possible way of visualizing this data so as to be either random and/or without replacement.

The confidence intervals obtained all used 12 or fewer degrees of freedom in the χ^2 distribution. This tends to produce unreliable confidence intervals.

To use the exponential distribution rate of further tests it is strongly recommended that (1) larger sample sizes be used, and (2) testing without replacement be used.

Procedure Used for Exponential Distribution of Failures

The exponential distribution is defined as follows:

$$f(t,o) = \begin{cases} \frac{1}{o} e - \frac{1}{o} t & \text{, for } 0,\ t > 0 \\ o & \text{, for } t \leq 0 \end{cases}$$

The two-sided confidence interval is given by

$$\frac{2T}{X^2_{\frac{\alpha}{2}(2r+2)}} < o < \frac{2T}{X^2_{(1-\frac{\alpha}{2})(2r)}}$$

The above interval is based on fitting the data to the exponential distribution by a X^2 fit. This automatically assumes that the data was taken randomly.

Legend: T = the accumulated life time of all components on test

r = the total number of failures that occurred

n = the number of units tested

f_i = the number of failures after a given test measurements

$\overline{x_i}$ = the mean life test time (hours) for a given test measurement

α = given by confidence level = (1 -)100%

$$T = \sum_{i=1}^{k} \overline{X_i} f_i + (n-r)(2000)$$

k = the number of time intervals

To obtain T for the X^2 test requires sampling without replacement. With replacement, data would not give an unbiased estimate for 0.

The failure rate λ for the exponential distribution is given by $\lambda = \frac{1}{\theta}$.

PERCENT OF CATASTROPHIC FAILURES

ENVIRONMENT	MCE		HADLEY		D.B.		COAST COIL	
	D3172671	D3172922	D3172671	D3172922	D3172671	D3172922	D3172671	D3172922
Initial	0	0	0	0	8.34%	8.34%	0	0
Thermal Sterl'n	0	0	0	0	0	0	0	0
Terminal Pull	0	0	0	0	0	0	0	0
Temp.Rise	0	-	0	-	0	-	0	-
Shock	0	0	0	0	0	8.34%	0	0
Vibration	8.34%	0	0	0	0	8.34%	0	0
Moisture	0	0	0	16.68%	8.34%	16.68%	0	0
Cycling	0	0	0	25.00%	0	8.34%	0	0
168 Hr. Life	0	0	0	0	0	0	0	0
500 Hr. Life	0	0	0	0	0	0	0	0
1000 Hr. Life	0	0	0	0	8.34%	0	0	0
1500 Hr. Life	0	0	0	0	0	0	0	0
2000 Hr. Life	0	0	0	0	0	0	0	0
All Tests	8.34%	0	0	41.68%	25.00%	50.00%	0	0

PERCENT OF PARAMETRIC FAILURES

PART D3172671

M.C.E.

ENVIRONMENT	1	2	3	4	5	6	7	8	9	10	11	12 thru 21
Initial	100%	100%	100%	100%	91.68%	91.68%	91.68%	100%	100%	91.68%	0	0
Therm. Sterl'n.	100%	100%	100%	100%	75.00%	100%	100%	100%	100%	75.00%	0	-
Terminal Pull	100%	100%	25.00%	100%	75.00%	100%	100%	75.00%	100%	75.00%	0	-
Temp. Rise	100%	100%	100%	100%	83.40%	91.68%	100%	100%	100%	83.40%	0	-
Shock	100%	100%	100%	100%	83.40%	83.40%	91.68%	100%	100%	83.40%	0	-
Vibration	100%	100%	100%	100%	90.8%	90.8%	90.8%	100%	100%	81.8%	0	-
Moisture	100%	100%	100%	100%	81.8%	90.8%	100%	100%	100%	81.8%	0	0
Cycling	100%	100%	100%	100%	81.8%	90.8%	100%	90.8%	100%	81.8%	0	-
168 Hr. Life	90.0%	90.0%	20.0%	90.0%	40.0%	90.0%	90.0%	10.0%	100%	80.0%	0	-
500 Hr. Life	90.0%	100%	80.0%	90.0%	60.0%	90.0%	90.0%	90.0%	100%	80.0%	0	-
1000 Hr. Life	100%	100%	100%	100%	90.0%	90.0%	90.0%	100%	100%	80.0%	0	-
1500 Hr. Life	90.0%	90.0%	90.0%	80.0%	70.0%	90.0%	100%	80.0%	100%	80.0%	70.0%	-
2000 Hr. Life	100%	100%	100%	100%	70.0%	90.0%	100%	100%	100%	80.0%	0	-
All Tests	97.6%	98.5%	89.0%	96.8%	77.2%	90.5%	95.4%	86.5%	97.6%	81.9%	5.51%	0

PERCENT OF PARAMETRIC FAILURES
PART D3172671

HADLEY

ENVIRONMENT	1	2	3	4	5	6	7	8	9	10	11	12 thru 21
Initial	0	0	0	0	0	0	0	0	0	0	0	0
Therm.Sterl'n.	0	0	0	0	0	0	0	0	0	0	0	-
Terminal Pull	0	0	25.00%	0	0	0	0	0	0	0	0	-
Temp. Rise	0	0	0	0	0	0	0	0	0	0	0	-
Shock	0	0	0	0	0	0	0	0	0	0	0	-
Vibration	0	0	0	0	0	0	8.34%	8.34%	0	0	8.34%	-
Moisture	0	0	0	0	0	0	0	0	0	0	8.34%	0
Cycling	0	0	0	0	0	0	0	0	0	0	8.34%	-
168 Hr. Life	0	0	0	0	0	0	0	0	0	0	8.34%	-
500 Hr. Life	0	0	66.66%	0	0	0	0	50.00%	0	0	8.34%	-
1000 Hr. Life	0	0	0	0	0	0	0	0	0	0	8.34%	-
1500 Hr. Life	8.34%	8.34%	33.33%	0	8.34%	0	0	33.33%	0	0	8.34%	-
2000 Hr. Life	0	0	0	0	0	0	0	0	0	0	8.34%	-
All Tests	0.72%	0.72%	9.28%	0	0.72%	0	0.72%	7.86%	0	0	5.72%	0

PERCENT OF PARAMETRIC FAILURES
Part D3172671

COAST COIL

Environment	1	2	3	4	5	6	7	8	9	10	11	12 thru 21
Initial	0	0	0	0	0	0	0	0	0	0	0	0
Therm. Sterl'n.	0	0	0	0	0	0	0	0	0	0	0	-
Terminal Pull	0	0	0	0	0	0	0	0	0	0	0	-
Temp. Rise	0	0	0	0	0	0	0	0	0	0	0	-
Shock	0	0	0	0	0	0	0	0	0	0	0	-
Vibration	0	0	0	0	0	0	0	0	0	0	25.00%	-
Moisture	0	0	0	0	0	0	0	0	0	0	25.00%	0
Cycling	0	0	0	0	0	0	0	0	0	0	16.68%	-
168 Hr. Life	0	0	0	0	0	0	0	0	0	0	25.00%	-
500 Hr. Life	0	0	0	0	0	0	0	0	0	0	25.00%	-
1000 Hr. Life	0	0	0	0	0	0	0	0	0	0	25.00%	-
1500 Hr. Life	25.00%	33.33%	25.00%	0	8.34%	0	0	33.33%	0	0	33.33%	-
2000 Hr. Life	0	0	0	0	0	0	0	0	0	0	8.34%	-
All Tests	2.14%	2.86%	2.14%	0	0.72%	0	0	2.86%	0	0	15.71%	0

PERCENT OF PARAMETRIC FAILURES
PART D3172671

D.B. PRODUCTS

Environment	1	2	3	4	5	6	7	8	9	10	11	12
Initial	0	0	100%	0	0	0	0	100%	0	0	0	27.3%
Therm. Sterl'n.	0	0	100%	0	0	0	0	100%	0	0	0	-
Terminal Pull	0	0	100%	0	0	0	0	100%	0	0	0	-
Temp. Rise	0	0	100%	0	0	0	0	100%	0	9.08%	0	-
Shock	0	0	81.8%	0	0	0	0	54.5%	0	9.08%	0	-
Vibration	0	0	63.6%	0	0	0	0	54.5%	0	0	0	-
Moisture	0	0	70.0%	0	0	0	0	50.0%	10.0%	0	0	20.0%
Cycling	0	0	30.0%	0	0	0	0	30.0%	0	0	0	-
168 Hr. Life	0	0	60.0%	0	10.0%	0	0	70.0%	10.0%	0	0	-
500 Hr. Life	0	0	20.0%	0	0	0	0	30.0%	10.0%	0	0	-
1000 Hr. Life	0	0	33.3%	0	0	0	0	22.2%	0	0	0	-
1500 Hr. Life	0	0	77.8%	0	0	0	0	77.7%	0	0	0	-
2000 Hr. Life	0	11.1%	100%	11.1%	22.2%	0	0	88.9%	0	0	0	-
All Tests	0	0.84%	74.8%	0.84%	2.52%	0	0	64.7%	2.52%	1.68%	0	23.8%

(Continued)

PERCENT OF PARAMETRIC FAILURES
PART D3172671

D. B. Products (Continued)

Environment	13	14	15	16	17	18	19	20	21
Initial	18.2%	0	36.4%	9.08%	0	0	0	27.3%	27.3%
Moisture	20.0%	0	30.0%	10.0%	0	0	0	20.0%	20.0%
All Tests	19.0%	0	33.3%	9.54%	0	0	0	23.8%	23.8%

EXPONENTIAL DISTRIBUTION
CATASTROPHIC FAILURE RATE IN PERCENT PER 1000 HOURS

Part D3172671

Vendor	Group	Confidence Level 90%	Confidence Level 60%	Confidence Level 50%
MCE	1	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	2	$\lambda < 21.4\%$	$\lambda < 11.5\%$	$\lambda < 9.90\%$
	1 & 2	$\lambda < 15.0\%$	$\lambda < 8.05\%$	$\lambda < 6.94\%$
Hadley	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$\lambda < 18.7\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	1 & 2	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$
D.B.	1	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	2	$0.48\% < \lambda < 44.1\%$	$2.08\% < \lambda < 27.9\%$	$2.70\% < \lambda < 25.0\%$
	1 & 2	$0.31\% < \lambda < 27.3\%$	$1.33\% < \lambda < 17.9\%$	$1.73\% < \lambda < 16.1\%$
Coast Coil	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$\lambda < 18.7\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	1 & 2	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$

Part D3172922

Vendor	Group	Confidence Level 90%	Confidence Level 60%	Confidence Level 50%
MCE	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$\lambda < 18.7\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	3 & 4	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$
Hadley	3	$\lambda < 100\%$	$\lambda < 80.5\%$	$\lambda < 69.4\%$
	4	$\lambda < 25.0\%$	$\lambda < 13.4\%$	$\lambda < 11.5\%$
	3 & 4	$\lambda < 21.4\%$	$\lambda < 11.5\%$	$\lambda < 9.90\%$
D.B.	3	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	4	$\lambda < 75.0\%$	$\lambda < 40.2\%$	$\lambda < 34.6\%$
	3 & 4	$\lambda < 30.0\%$	$\lambda < 16.1\%$	$\lambda < 13.8\%$
Coast Coil	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$\lambda < 18.7\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	3 & 4	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 1

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$0.34\% < \lambda < 31.1\%$	$1.46\% < \lambda < 19.6\%$	$1.90\% < \lambda < 17.8\%$
	1 & 2	$0.22\% < \lambda < 20.2\%$	$0.95\% < \lambda < 12.7\%$	$1.23\% < \lambda < 11.5\%$
D.B.	1	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	2	$\lambda < 25.0\%$	$\lambda < 13.4\%$	$\lambda < 11.5\%$
	1 & 2	$\lambda < 16.6\%$	$\lambda < 8.95\%$	$\lambda < 7.70\%$
Coast Coil	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$5.94\% < \lambda < 56.4\%$	$11.2\% < \lambda < 40.2\%$	$12.6\% < \lambda < 37.2\%$
	1 & 2	$3.76\% < \lambda < 35.8\%$	$7.06\% < \lambda < 25.4\%$	$7.94\% < \lambda < 23.6\%$

* No estimation can be made

1 100% failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 2

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	$0.71\% < \lambda < 65.5\%$	$3.08\% < \lambda < 41.4\%$	$4.00\% < \lambda < 37.2\%$
	2	$\lambda < 18.8\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	1 & 2	$0.22\% < \lambda < 20.4\%$	$0.96\% < \lambda < 12.9\%$	$1.25\% < \lambda < 11.6\%$
D.B.	1	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	2	$0.44\% < \lambda < 40.4\%$	$1.90\% < \lambda < 25.5\%$	$2.46\% < \lambda < 22.9\%$
	1 & 2	$0.29\% < \lambda < 26.8\%$	$1.26\% < \lambda < 16.9\%$	$1.63\% < \lambda < 15.2\%$
Coast Coil	1	$5.39\% < \lambda < 96.8\%$	$12.6\% < \lambda < 65.9\%$	$14.8\% < \lambda < 60.4\%$
	2	$2.42\% < \lambda < 43.4\%$	$5.68\% < \lambda < 29.6\%$	$6.62\% < \lambda < 27.0\%$
	1 & 2	$1.56\% < \lambda < 28.0\%$	$3.66\% < \lambda < 19.1\%$	$4.27\% < \lambda < 17.4\%$

*No estimation can be made

1 100% failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 3

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*2	*2	*2
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
D.B.	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
Coast Coil	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$5.94\% < \lambda < 56.4\%$	$11.2\% < \lambda < 40.2\%$	$12.6\% < \lambda < 37.2\%$
	1 & 2	$3.76\% < \lambda < 35.8\%$	$7.06\% < \lambda < 25.4\%$	$7.94\% < \lambda < 23.6\%$

*No estimation can be made

2 100% failure by end of life test

EXPONENTIAL DISTRIBUTION
PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS
PART D3172671

Parameter 4

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%
D.B.	1	$\lambda <$ 50.0%	$\lambda <$ 26.8%	$\lambda <$ 23.1%
	2	0.44% $< \lambda <$ 40.4%	1.90% $< \lambda <$ 25.5%	2.46% $< \lambda <$ 22.9%
	1 & 2	0.29% $< \lambda <$ 26.8%	1.26% $< \lambda <$ 16.9%	1.63% $< \lambda <$ 15.2%
Coast Coil	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%

*No estimation can be made

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 5

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$0.34\% < \lambda < 31.1\%$	$1.46\% < \lambda < 19.6\%$	$1.90\% < \lambda < 17.8\%$
	1 & 2	$0.22\% < \lambda < 20.2\%$	$0.95\% < \lambda < 12.7\%$	$1.23\% < \lambda < 11.5\%$
D.B.	1	$0.25\% < \lambda < 100\%$	$1.07\% < \lambda \leq 100\%$	$1.39\% < \lambda \leq 100\%$
	2	$0.44\% < \lambda < 40.4\%$	$1.90\% < \lambda < 25.5\%$	$2.46\% < \lambda < 22.9\%$
	1 & 2	$2.24\% < \lambda < 39.6\%$	$5.20\% < \lambda < 27.0\%$	$6.05\% < \lambda < 24.7\%$
Coast Coil	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$0.34\% < \lambda < 31.1\%$	$1.46\% < \lambda < 19.6\%$	$1.90\% < \lambda < 17.8\%$
	1 & 2	$0.22\% < \lambda < 20.2\%$	$0.95\% < \lambda < 12.7\%$	$1.23\% < \lambda < 11.5\%$

*No estimation can be made.

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 6

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*2	*2	*2
	1 & 2	*	*	*
Hadley	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%
D.B.	1	$\lambda <$ 50.0%	$\lambda <$ 26.8%	$\lambda <$ 23.1%
	2	$\lambda <$ 25.0%	$\lambda <$ 13.4%	$\lambda <$ 11.5%
	1 & 2	$\lambda <$ 16.6%	$\lambda <$ 8.95%	$\lambda <$ 7.70%
Coast Coil	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%

*No estimation can be made

1 100% failure

2 85.8% failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 7

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*2	*2	*2
	1 & 2	*	*	*
Hadley	1	$\lambda<37.5\%$	$\lambda<20.1\%$	$\lambda<17.3\%$
	2	$\lambda<18.8\%$	$\lambda<10.05\%$	$\lambda<8.65\%$
	1 & 2	$\lambda<12.5\%$	$\lambda<6.70\%$	$\lambda<5.77\%$
D.B.	1	$\lambda<50.0\%$	$\lambda<26.8\%$	$\lambda<23.1\%$
	2	$\lambda<25.0\%$	$\lambda<13.4\%$	$\lambda<11.5\%$
	1 & 2	$\lambda<16.6\%$	$\lambda<8.95\%$	$\lambda<7.70\%$
Coast Coil	1	$\lambda<37.5\%$	$\lambda<20.1\%$	$\lambda<17.3\%$
	2	$\lambda<18.8\%$	$\lambda<10.05\%$	$\lambda<8.65\%$
	1 & 2	$\lambda<12.5\%$	$\lambda<6.70\%$	$\lambda<5.77\%$

*No estimation can be made

1 100% failures

2 100% failures by end of test

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 8

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
Hadley	1	*	*	*
	2	$16.6\% < \lambda < 88.4\%$	$25.9\% < \lambda < 66.4\%$	$28.2\% < \lambda < 62.3\%$
	1 & 2	*	*	*
D.B.	1	*	*	*
	2	*	*	*
	1 & 2	*	*	*
Coast Coil	1	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	2	$10.5\% < \lambda < 70.4\%$	$17.7\% < \lambda < 51.7\%$	$19.5\% < \lambda < 48.3\%$
	1 & 2	$6.50\% < \lambda < 43.6\%$	$10.9\% < \lambda < 32.0\%$	$12.1\% < \lambda < 29.9\%$

*No estimation can be made

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 9

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*1	*1	*1
	1 & 2	*1	*1	*1
Hadley	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%
D.B.	1	$\lambda <$ 50.0%	$\lambda <$ 26.8%	$\lambda <$ 23.1%
	2	0.43% $< \lambda <$ 39.2%	1.85% $< \lambda <$ 24.8%	2.40% $< \lambda <$ 22.4%
	1 & 2	0.28% $< \lambda <$ 26.2%	1.23% $< \lambda <$ 16.6%	1.61% $< \lambda <$ 14.9%
Coast Coil	1	$\lambda <$ 37.5%	$\lambda <$ 20.1%	$\lambda <$ 17.3%
	2	$\lambda <$ 18.8%	$\lambda <$ 10.05%	$\lambda <$ 8.65%
	1 & 2	$\lambda <$ 12.5%	$\lambda <$ 6.70%	$\lambda <$ 5.77%

***No estimation can be made**

1 100% failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 10

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	*1	*1	*1
	2	*2	*2	*2
	1 & 2	*	*	*
Hadley	1	$\lambda<37.5\%$	$\lambda<20.1\%$	$\lambda<17.3\%$
	2	$\lambda<18.8\%$	$\lambda<10.05\%$	$\lambda<8.65\%$
	1 & 2	$\lambda<12.5\%$	$\lambda<6.70\%$	$\lambda<5.77\%$
D.B.	1	$\lambda<50.0\%$	$\lambda<26.8\%$	$\lambda<23.1\%$
	2	$\lambda<25.5\%$	$\lambda<13.4\%$	$\lambda<11.5\%$
	1 & 2	$\lambda<16.6\%$	$\lambda<8.95\%$	$\lambda<7.70\%$
Coast Coil	1	$\lambda<37.5\%$	$\lambda<20.1\%$	$\lambda<17.3\%$
	2	$\lambda<18.8\%$	$\lambda<10.05\%$	$\lambda<8.65\%$
	1 & 2	$\lambda<12.5\%$	$\lambda<6.70\%$	$\lambda<5.77\%$

*No estimation can be made

1 66.6% failures

2 85.8% failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172671

Parameter 11

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	1	$1.96\% < \lambda < 100\%$	$8.50\% < \lambda < 100\%$	$11.0\% < \lambda < 100\%$
	2	*2	*2	*2
	1 & 2	*	*	*
Hadley	1	$0.85\% < \lambda < 78.0\%$	$3.67\% < \lambda < 49.4\%$	$4.76\% < \lambda < 44.3\%$
	2	$\lambda < 18.8\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	1 & 2	$0.39\% < \lambda < 33.7\%$	$1.59\% < \lambda < 21.3\%$	$2.06\% < \lambda < 19.1\%$
D.B.	1	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	2	$\lambda < 25.0\%$	$\lambda < 13.4\%$	$\lambda < 11.5\%$
	1 & 2	$\lambda < 16.6\%$	$\lambda < 8.95\%$	$\lambda < 7.70\%$
Coast Coil	1	*	*	*
	2	$7.20\% < \lambda < 68.5\%$	$13.5\% < \lambda < 48.6\%$	$15.2\% < \lambda < 45.1\%$
	1 & 2	*	*	*

*No estimation can be made

2 85.8% failures

PERCENT OF PARAMETRIC FAILURES
PART D3172922

ENVIRONMENT	Parameter: 1 MCE	HADLEY	D.B.	C.C.	2 MCE	HADLEY	D.B.	C.C.	3 MCE	HADLEY	D.B.	C.C.	4 MCE	HADLEY	D.B.	C.C.
Initial	0	0	27.3%	0	41.68%	25.00%	0	0	0	0	9.08%	0	0	0	0	0
Therm.Ster.	0	0	0	0	100%	25.0%	0	0	0	0	0	0	-	-	-	-
Term.Pull	0	25.0%	25.0%	0	75.0%	0	0	0	0	0	0	0	-	-	-	-
Shock	0	0	11.1%	0	66.66%	25.0%	0	0	0	0	0	0	-	-	-	-
Vibration	0	0	11.1%	0	41.68%	25.0%	0	0	0	0	0	0	-	-	-	-
Moisture	0	0	16.6%	0	66.66%	25.0%	0	0	8.34%	50.0%	16.66%	0	9.34%	12.5%	0	0
Cycling	0	0	16.6%	0	75.0%	14.3%	0	0	25.0%	0	0	0	-	-	-	-
168 Hr. Life	0	0	0	0	91.68%	14.3%	20.0%	0	0	0	0	0	-	-	-	-
500 Hr. Life	0	0	0	0	66.66%	14.3%	0	0	0	0	0	0	-	-	-	-
1000 Hr.Life	0	0	0	0	75.0%	14.3%	0	0	0	0	0	0	-	-	-	-
1500 Hr.Life	0	0	0	0	75.0%	14.3%	0	0	0	0	0	0	-	-	-	-
2000 Hr.Life	0	0	0	12.5%	83.4%	14.3%	0	0	8.34%	0	0	0	-	-	-	-
All Tests	0	0.78%	10.8%	0.78%	69.5%	19.2%	1.35%	0	3.91%	4.30%	2.70%	0	4.16%	5.00%	0	0

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172922

Parameter 1

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$\lambda < 18.8\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	3 & 4	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$
Hadley	3	$\lambda \leq 100\%$	$\lambda < 80.5\%$	$\lambda < 69.4\%$
	4	$\lambda < 25.0\%$	$\lambda < 13.4\%$	$\lambda < 11.5\%$
	3 & 4	$\lambda < 21.4\%$	$\lambda < 11.5\%$	$\lambda < 9.90\%$
D.B.	3	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	4	$\lambda < 75.0\%$	$\lambda < 40.2\%$	$\lambda < 34.6\%$
	3 & 4	$\lambda < 30.0\%$	$\lambda < 16.1\%$	$\lambda < 13.8\%$
Coast	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
Coil	4	$0.33\% < \lambda < 30.1\%$	$1.42\% < \lambda < 19.0\%$	$1.84\% < \lambda < 17.0\%$
	3 & 4	$0.22\% < \lambda < 20.0\%$	$0.94\% < \lambda < 12.6\%$	$1.22\% < \lambda < 11.4\%$

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172922

Parameter 2

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	3	*1	*1	*1
	4	*	*	*
	3 & 4	*	*	*
Hadley	3	$\lambda \leq 100\%$	$\lambda < 80.5\%$	$\lambda < 69.4\%$
	4	$0.51\% < \lambda < 47.0\%$	$2.22\% < \lambda < 29.8\%$	$2.88\% < \lambda < 26.8\%$
	3 & 4	$0.43\% < \lambda < 39.3\%$	$1.85\% < \lambda < 24.8\%$	$2.40\% < \lambda < 22.4\%$
D.B.	3	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	4	$2.47\% < \lambda < 100\%$	$10.7\% < \lambda < 100\%$	$13.9\% < \lambda < 100\%$
	3 & 4	$0.64\% < \lambda < 58.7\%$	$2.76\% < \lambda < 37.1\%$	$3.59\% < \lambda < 33.4\%$
Coast Coil	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$\lambda < 18.8\%$	$\lambda < 10.05\%$	$\lambda < 3.65\%$
	3 & 4	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$

*No estimation can be made

1 100% Failures

EXPONENTIAL DISTRIBUTION

PARAMETRIC FAILURE RATE IN PERCENT PER 1000 HOURS

PART D3172922

Parameter 3

Vendor	Group	CONFIDENCE LEVEL 90%	60%	50%
MCE	3	$\lambda < 37.5\%$	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$0.33\% < \lambda < 30.1\%$	$1.42\% < \lambda < 19.0\%$	$1.84\% < \lambda < 17.1\%$
	3 & 4	$0.22\% < \lambda < 20.0\%$	$0.94\% < \lambda < 12.6\%$	$1.22\% < \lambda < 11.4\%$
Hadley	3	$\lambda < 100\%$	$\lambda < 80.5\%$	$\lambda < 69.4\%$
	4	$\lambda < 25.0\%$	$\lambda < 13.4\%$	$\lambda < 11.5\%$
	3 & 4	$\lambda < 21.4\%$	$\lambda < 11.5\%$	$\lambda < 9.90\%$
D.B.	3	$\lambda < 50.0\%$	$\lambda < 26.8\%$	$\lambda < 23.1\%$
	4	$\lambda < 75.0\%$	$\lambda < 40.2\%$	$\lambda < 34.6\%$
	3 & 4	$\lambda < 30.0\%$	$\lambda < 16.1\%$	$\lambda < 13.8\%$
Coast Coil	3	$\lambda <$ [illegible]	$\lambda < 20.1\%$	$\lambda < 17.3\%$
	4	$\lambda < 18.8\%$	$\lambda < 10.05\%$	$\lambda < 8.65\%$
	3 & 4	$\lambda < 12.5\%$	$\lambda < 6.70\%$	$\lambda < 5.77\%$

Weibull Distribution of Failures

The Weibull distribution is defined as follows:

$$f(t,\alpha,\beta) = \begin{cases} \dfrac{\beta\, t^{\beta-1}}{\alpha} e^{-\frac{1}{\alpha}t^{\beta}} & , \text{ for } \alpha, \beta, t > 0 \\ 0 & , \text{ elsewhere} \end{cases}$$

The failure rate is given by

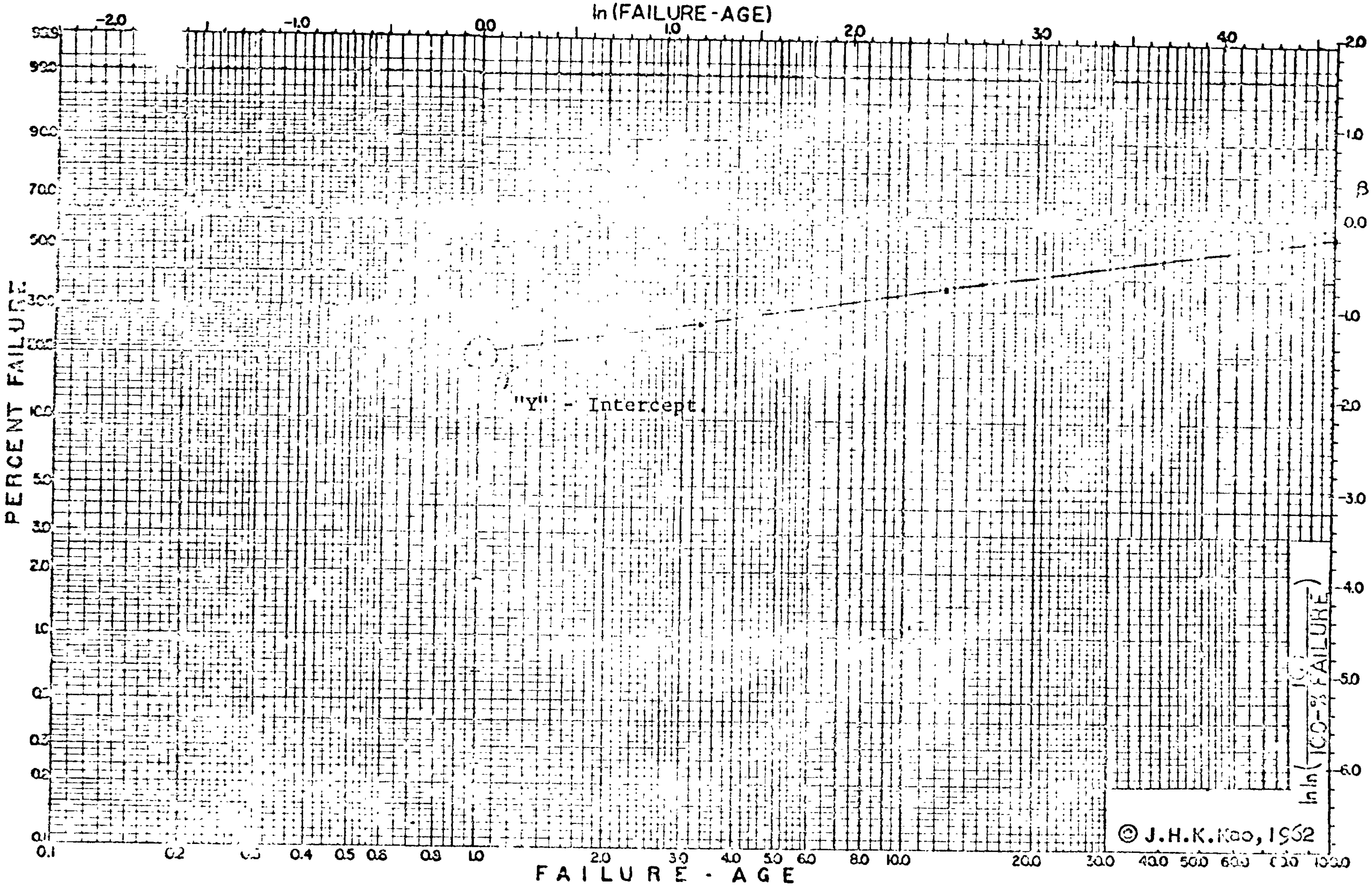
$$g(t) = \begin{cases} \dfrac{\beta}{\alpha} t^{\beta-1} & , \text{ for } t > 0 \\ 0 & , \text{ elsewhere} \end{cases}$$

Where t is times and α and β are parameters determined by the test data.

All comments made for the exponential distribution also apply here. The data must be random and without replacement of parts that have failed.

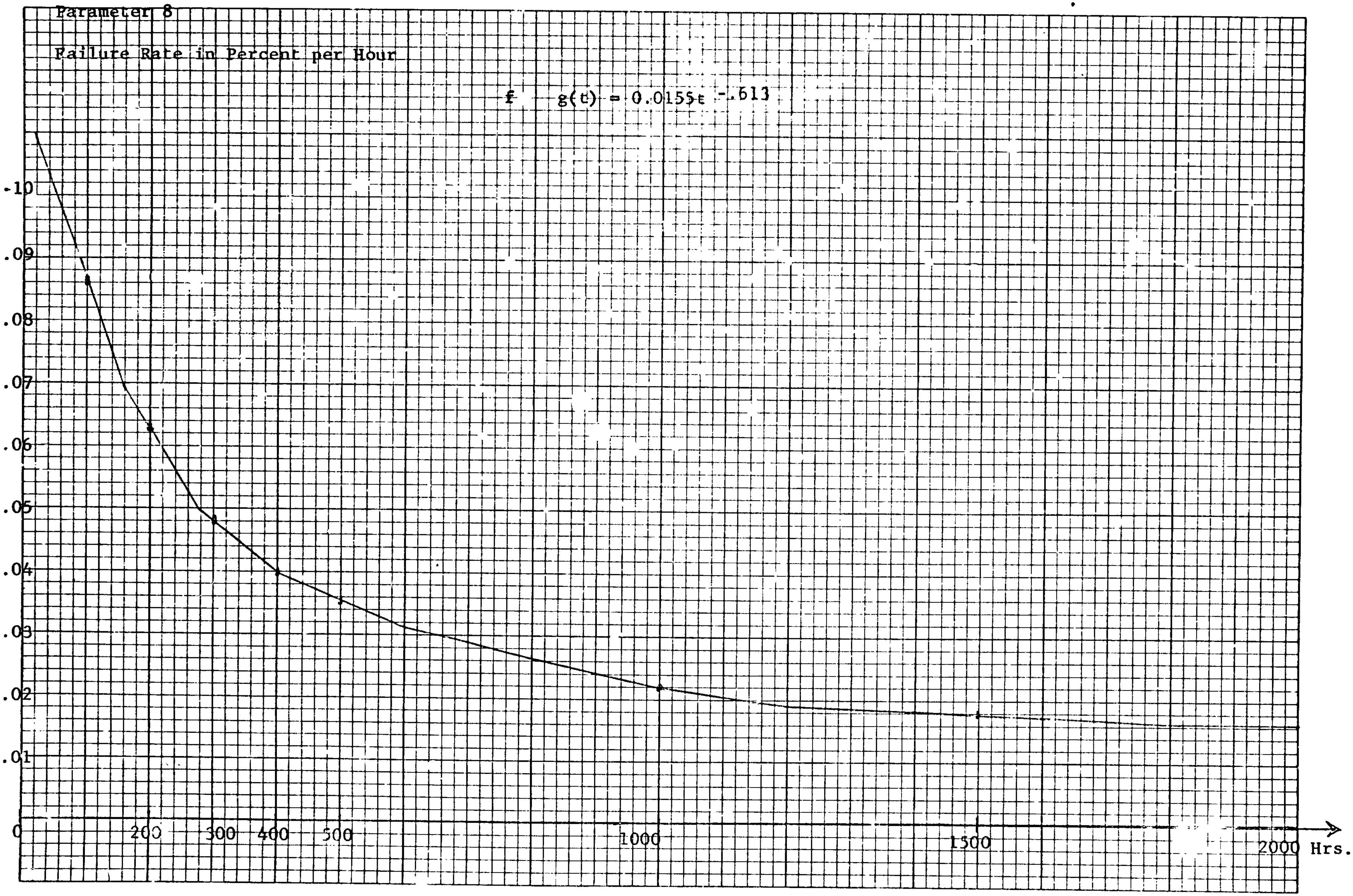
To determine α & β failures must appear in at least two different time intervals. This requirement, along with the afore mentioned requirements for the exponential distribution, allowed only two Weibull failure graphs

D3172671
Hadley
Parameter 8

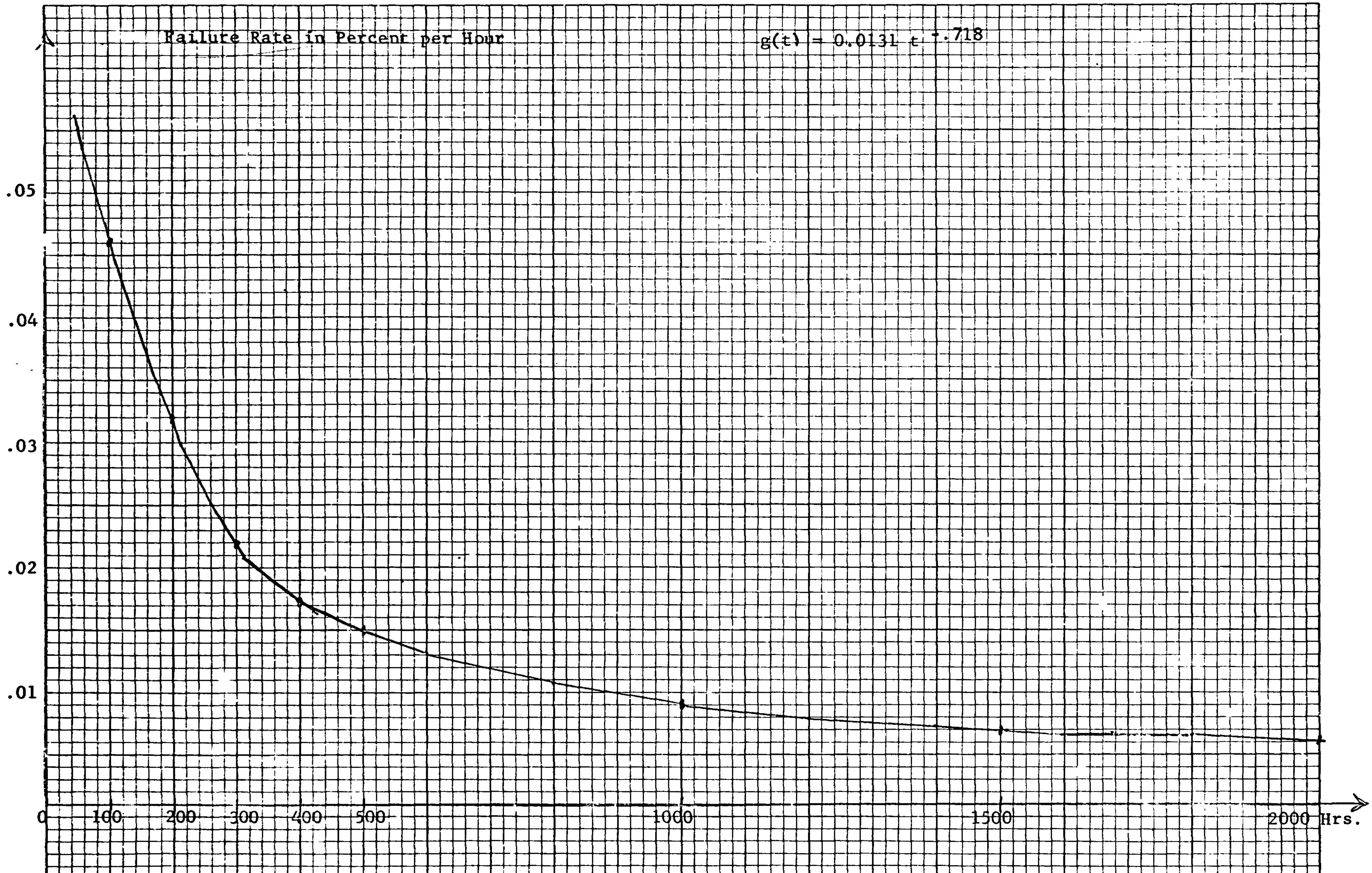


1 Unit - 100 Hours

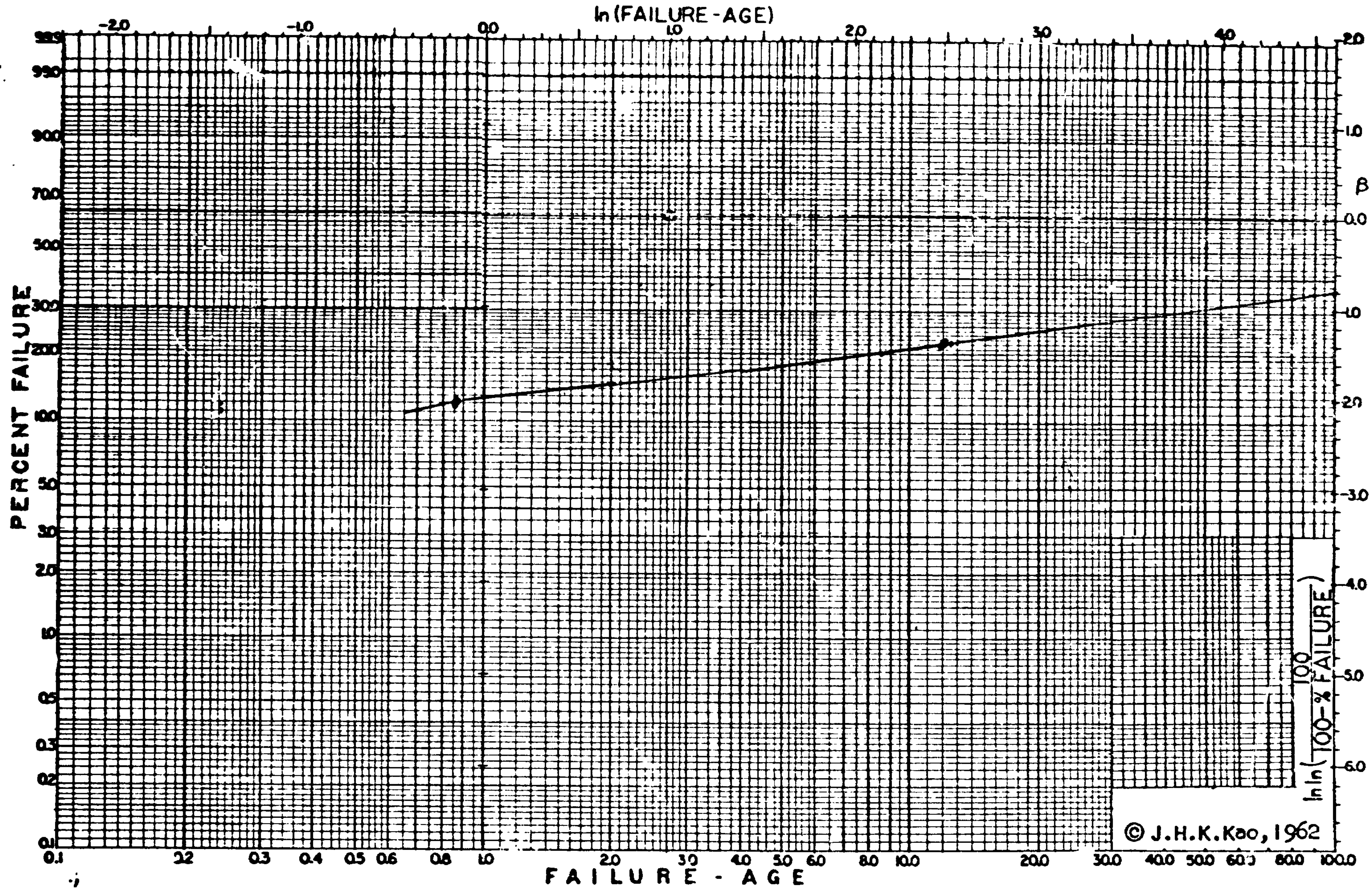
Part D3172671
Vendor Hadley
Parameter 8



Part D3172671
Vendor Coast Coil, Parameter 11



D3172671
Coast Coil
Parameter 11



5.0 Discussion of Test Results

5.1 Part Number D3172671

5.1.1 Magnetic Circuit Elements, Inc.

The high percentage of "Out of Tolerance" Failures (41.6%) was caused by non-conformance to design. Low D. C. Resistance measurements of all windings indicate fewer turns per winding than those specified in Test Procedure 902.66-01. The deficit in turns prevented operation of the transformer with the specified input of 30V RMS, 2400 cps. Satisfactory operation was obtained by increasing frequency of the source E.M.F. to 6000 cps. The higher frequency was used for all Excitation Current measurements and during the Temperature Rise test. This part is not interchangeable with parts submitted by the other three vendors because of basic differences in electrical characteristics. Materials used for the case and potting were unaffected by any of the environmental exposures.

5.1.2 Robert M. Hadley

Parts supplied by this vendor had the smallest percentage (1.2%) parameter failures and no catastrophic failures; however, the difference in lead configuration may prevent direct replacement with samples submitted by the other three vendors.

Materials used for the case and potting were unaffected by environmental exposures.

5.1.3 D. B. Products

This vendor's part proved to be the least reliable of all. The catastrophic failure rate was 25% with a relatively high parametric failure rate (7.7%). Materials used for the case and potting were severely damaged by heat during Thermal Sterilization and Temperature Rise tests.

5.1.4 Coast Coil

Parts supplied by this vendor were satisfactory in electrical and mechanical design and are considered to be superior to parts supplied by the other three vendors. There were no catastrophic failures, and parametric failures averaged 1.2% throughout the qualification test. Materials used for the case and potting were unaffected by environmental exposures.

5.2 Part D3172922

5.2.1 Magnetic Circuit Elements, Inc.

The relatively high percentage of Out of Tolerance failures (18.3%) was caused primarily by low D. C. Resistance of the secondary winding. There were no catastrophic failures. The thickness and/or number of layers of tape used on the outer surfaces was adequate and capable of resisting damage from environmental exposures and handling.

5.2.2 Robert M. Hadley

Four of the five catastrophic failures were caused by Insulation Resistance failure and are attributable to either the quality of insulating tape or the number of layers and taping methods used to cover the toroid surfaces.

5.2.3 D. B. Products

Catastrophic failures (50.0%) were caused primarily by insulating tape, same as paragraph 5.2.2 above.

5.2.4 Coast Coil

These parts are considered to be superior to similar parts supplied by the other three vendors, in that there were no Out of Tolerance or Catastrophic Failures.

5.2.5 C. T. Unbalance

The C. T. Unbalance of all windings, all units, both part types was well within the ± 1% limits.

6.0 Conclusions

6.1 The relatively small number of test specimens and test design prevented formation of accurate reliability estimates and comparisons.

6.2 Coast Coil products, both part types, were superior to those supplied by the other three vendors.

7.0 Recommendations

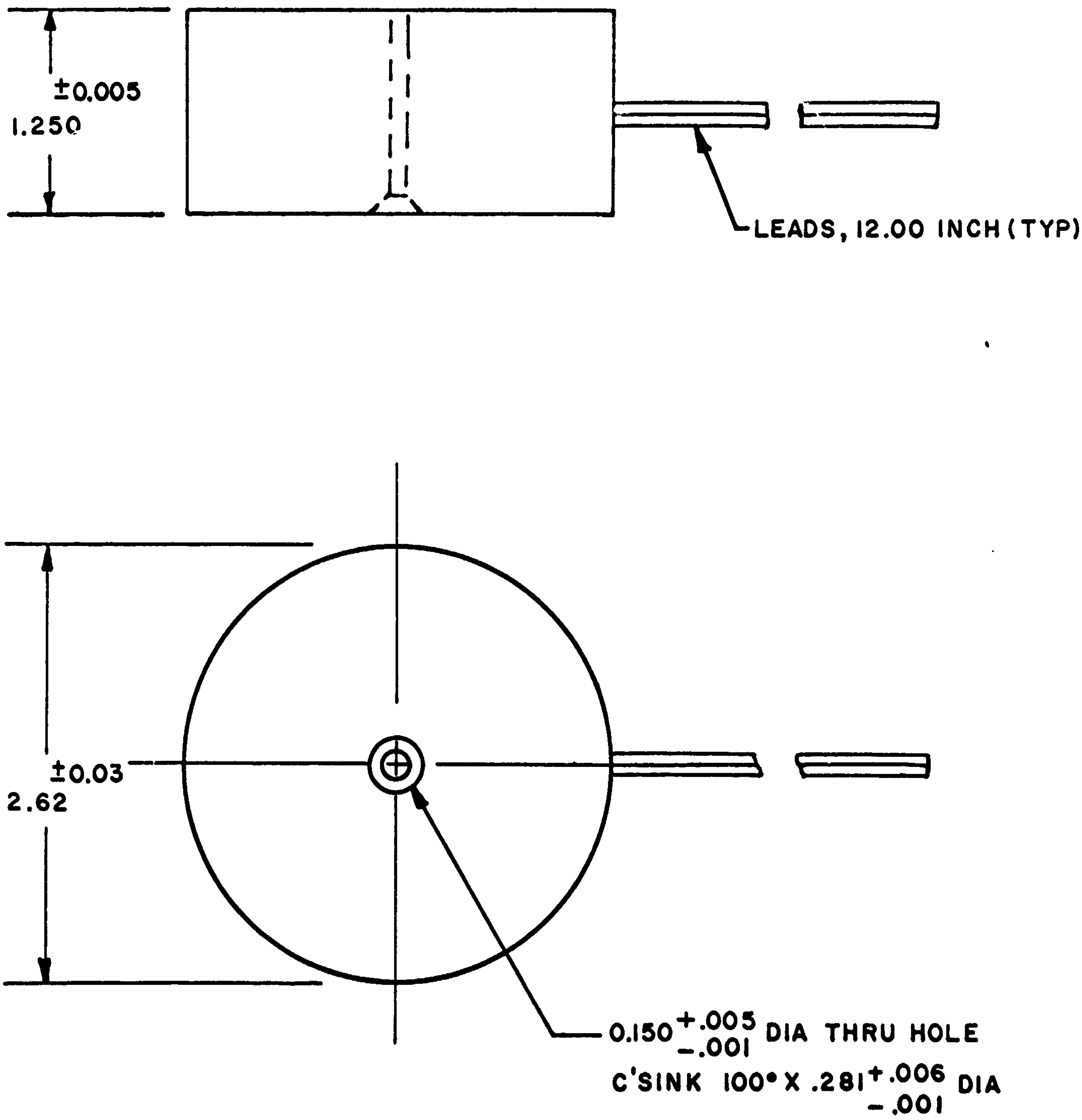
7.1 Future magnetic component qualification tests should be in accordance with specification MIL-T-27B.

7.2 Statistical data should be obtained solely from tests during Life. Relatively large numbers of test specimens should be tested with parameters such as Excitation Current, Load Voltage and No Load Voltages measured at frequent intervals. The test specimens should never be de-energized nor removed from ovens, if used, during the Life test. Life test samples should be divided into two groups, the first group loaded nominally, the second group with 10% overload.

7.3 Effects of the various environmental exposures may be determined by relatively small samples (i.e. six units).

FIG 1

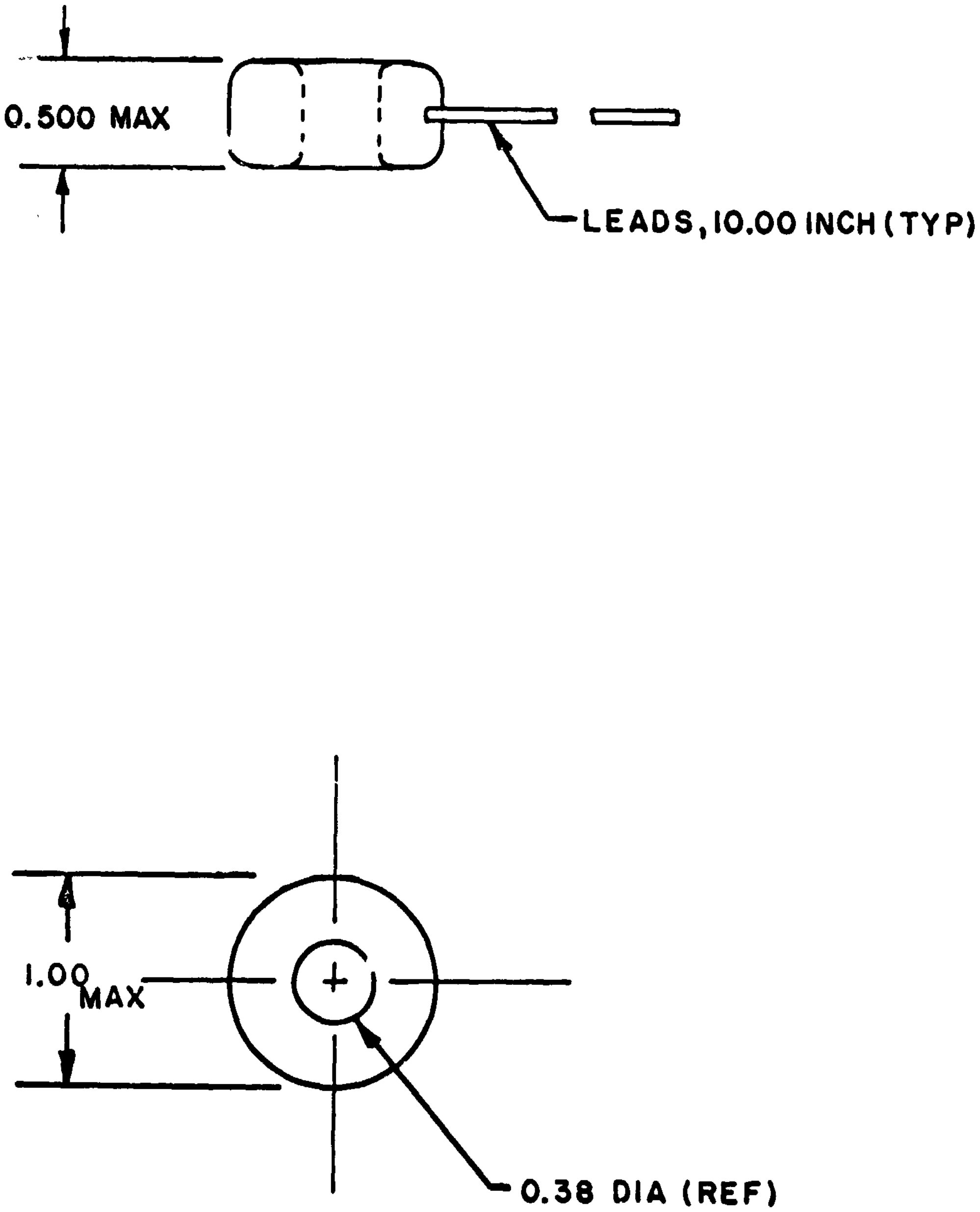
PHYSICAL DIMENSIONS, PART NO. D3172671



FULL SCALE

FIG 2

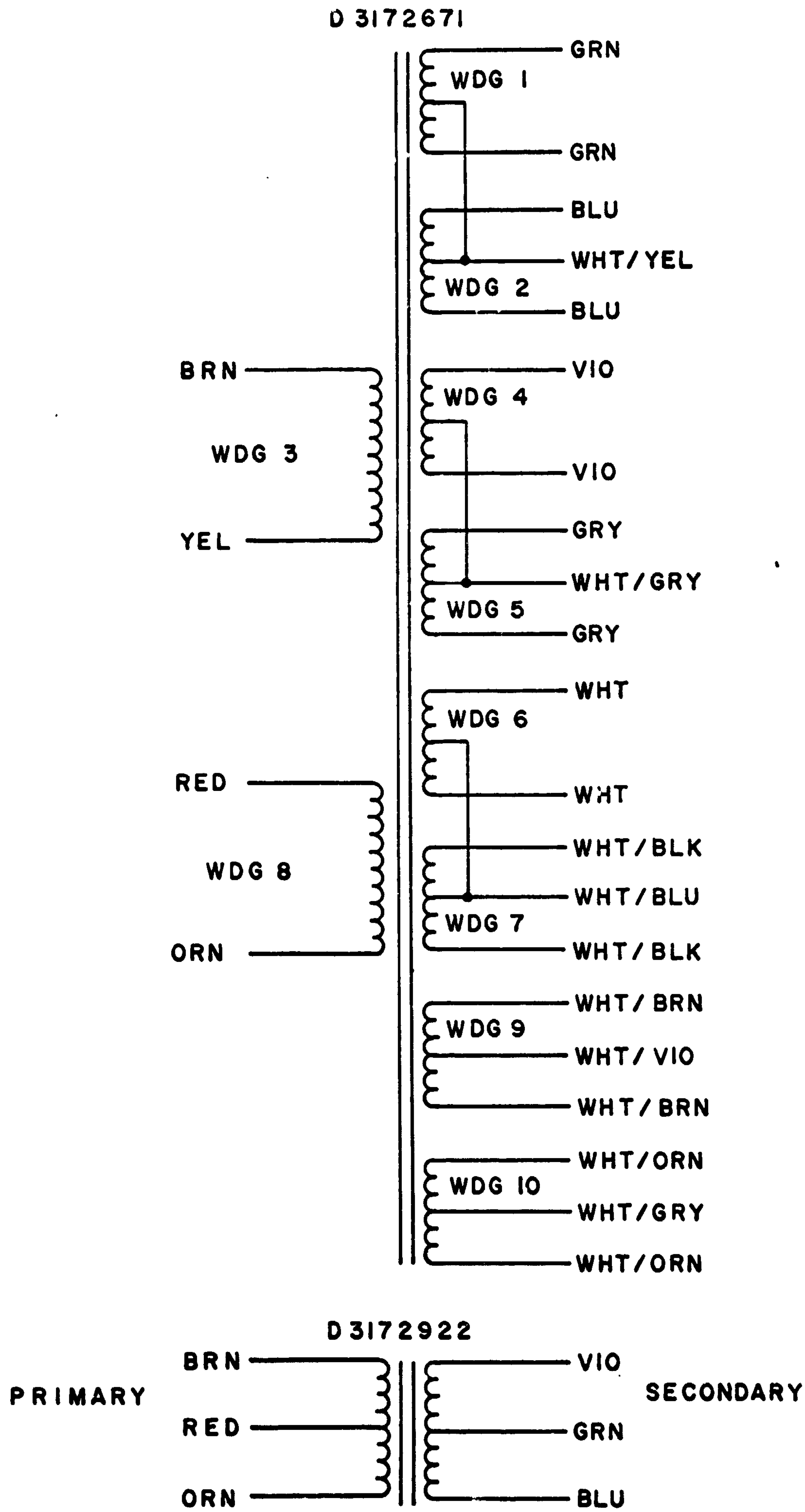
PHYSICAL DIMENSIONS, PART NO. D3172902



FULL SCALE

FIG 3

SCHEMATIC, PART NUMBERS



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FAILURE REPORT

REPORT NUMBER		
DATE MO.	DAY	YEAR

PART NAME	PART NO.	PART NO.(CUST)	SERIAL NO.
MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.)

TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC)

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ G ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR | DEPT

FAILURE ANALYSIS

DATE

FAILURE TYPE (CHECK)

① MECH. ____ ② ELECT ____ ③ OPER ____

MODE OF FAILURE

CAUSE OF FAILURE

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION ☐ DESIGN ☐ Q.C. ☐ MFG.	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)

CORRECTIVE ACTION EFFECTIVE ON:

RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

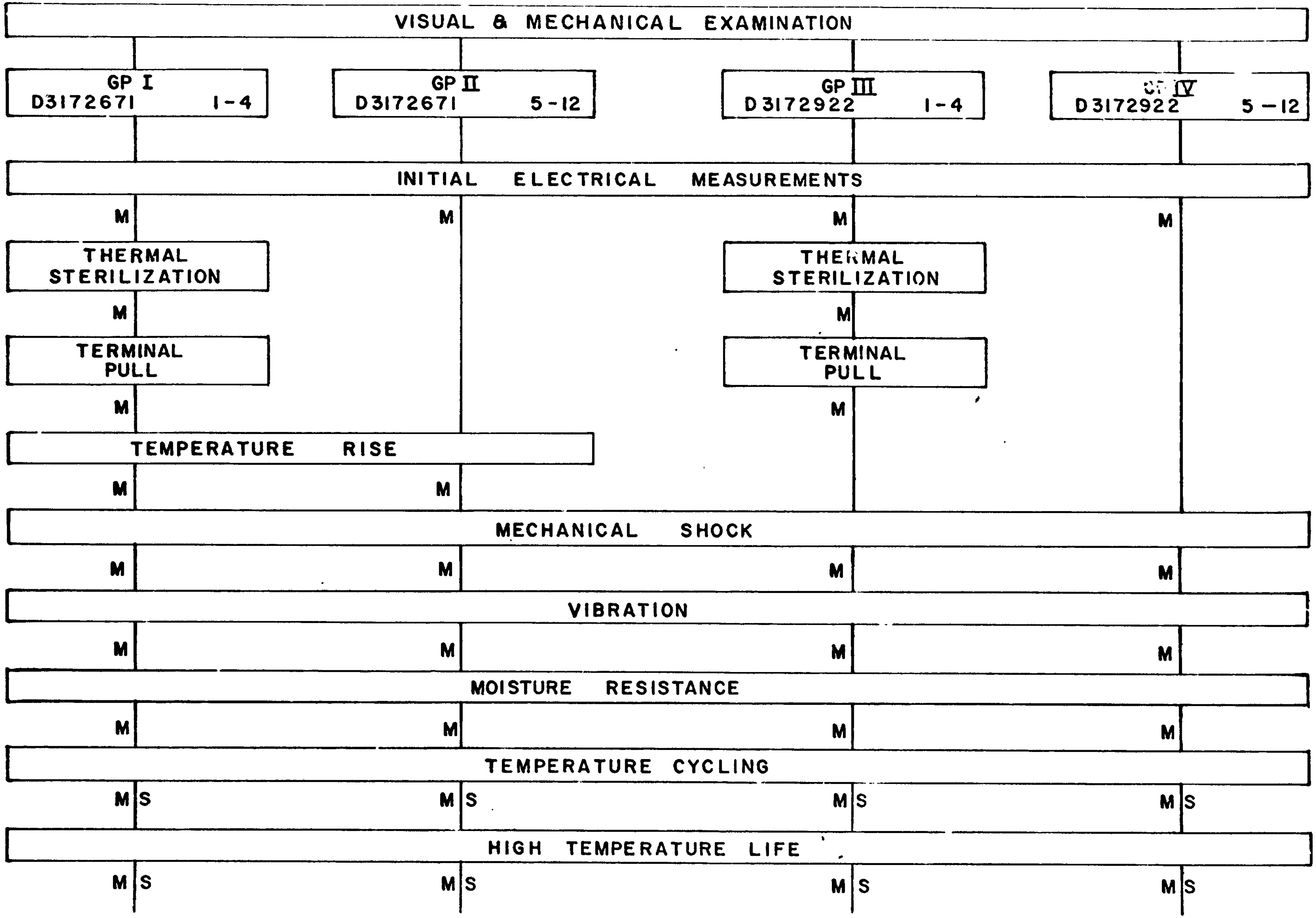
INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #255

FIG 11

FIG 4

FLOW CHART



M=DATA POINT MEASUREMENT

FIGURE 5

FLIP SWITCH BOX

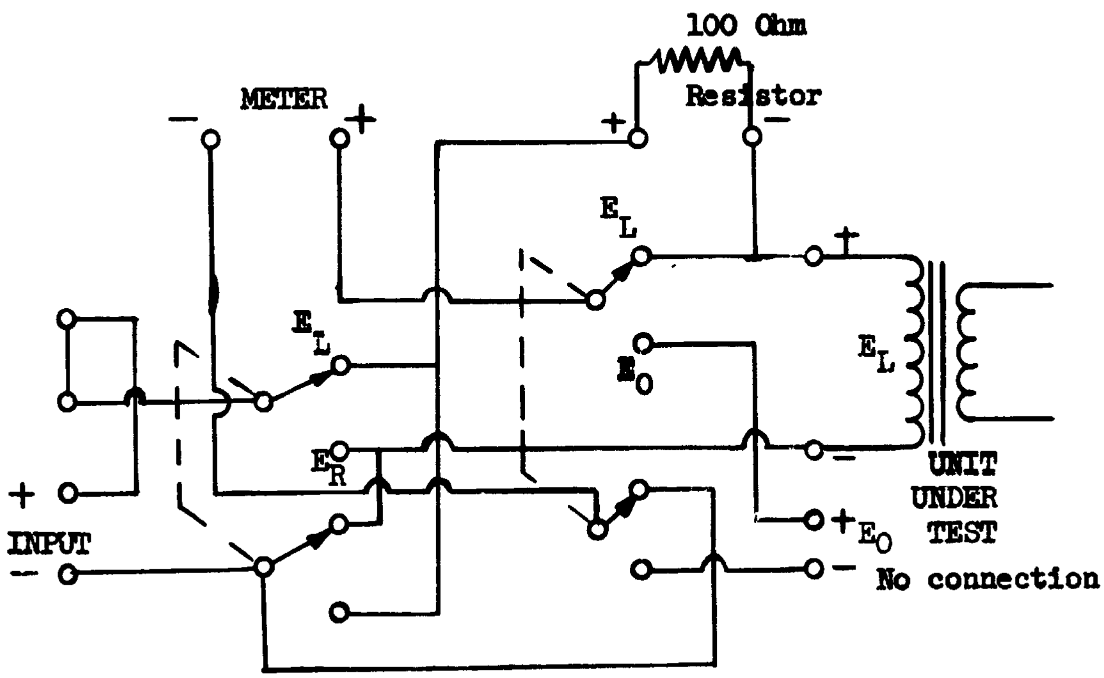


FIG 6

TURNS RATIO MEASUREMENTS

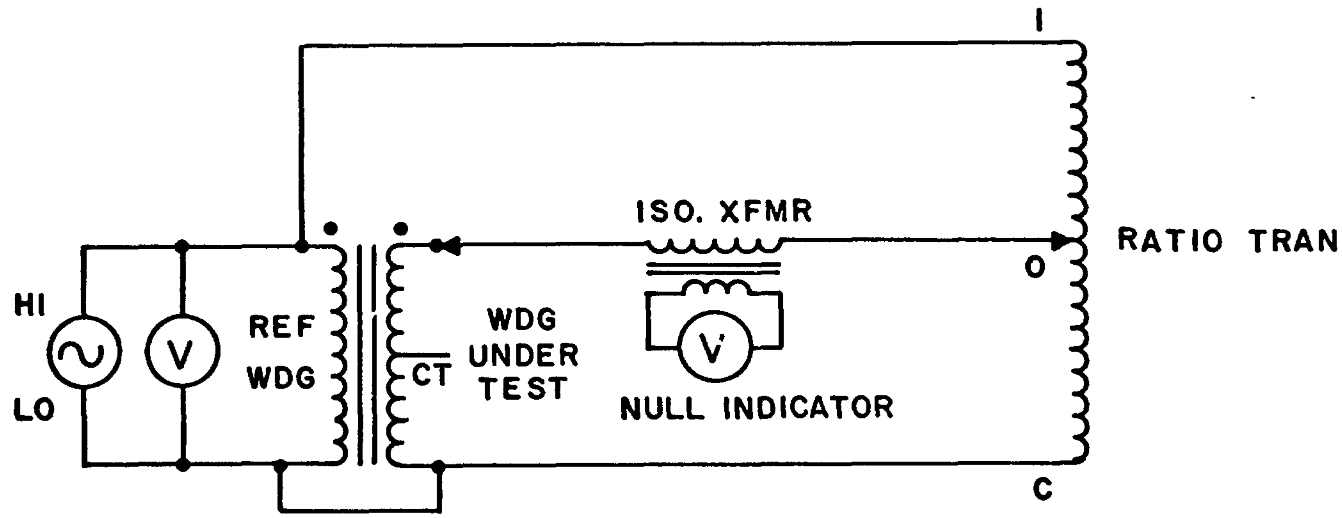
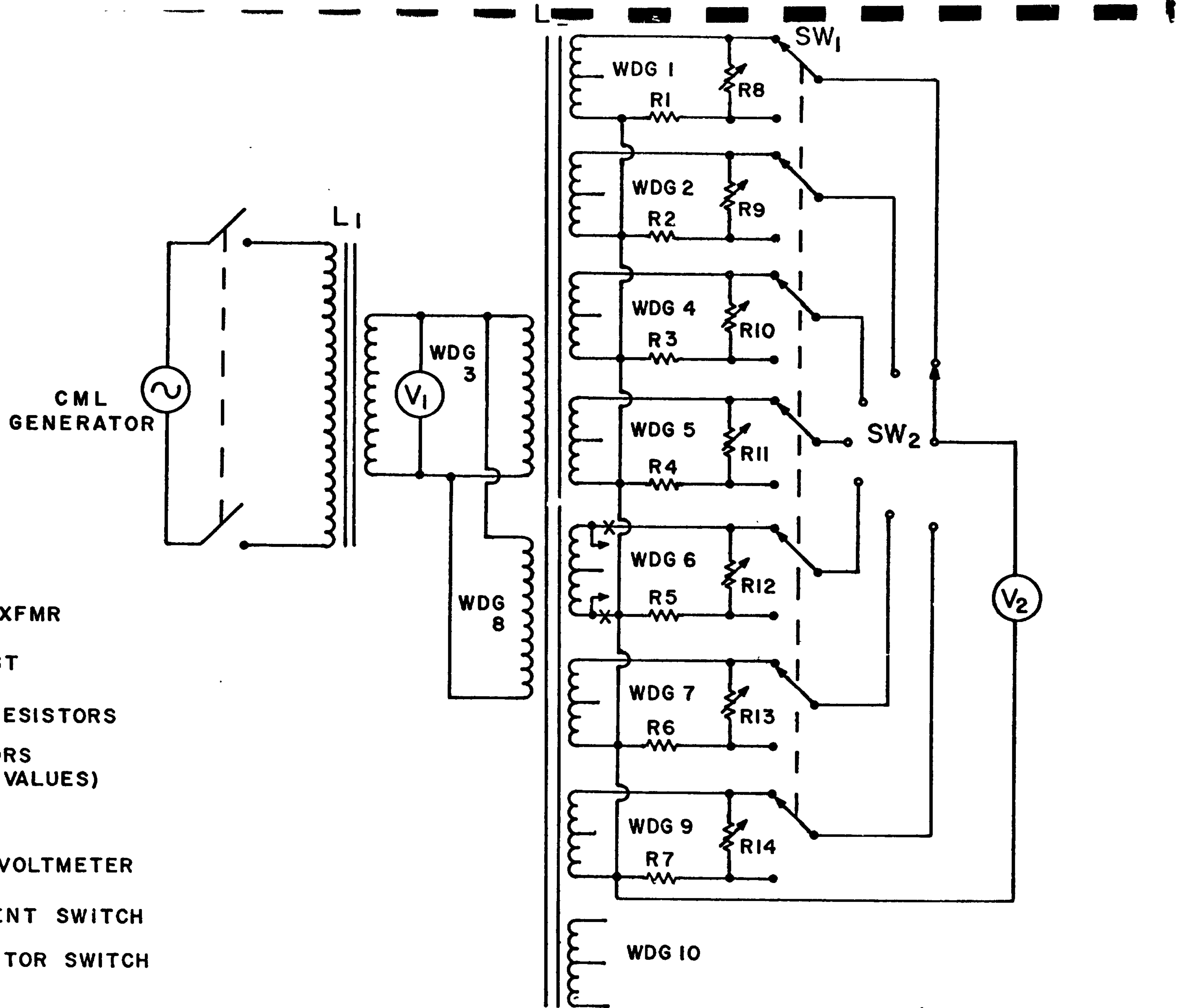


FIG. 7

TEMPERATURE RISE
LOAD CIRCUIT
PART NO. D3172671



L_1 = STEP DOWN PWR XFMR

L_2 = UNIT UNDER TEST

R1–R7 = 1 Ω, 10 WATT RESISTORS

R8–R14 = LOAD RESISTORS
(SEE TEXT FOR VALUES)

V_1 = HP400H

V_2 = CIMRON DIGITAL VOLTMETER

SW_1 = VOLTAGE - CURRENT SWITCH

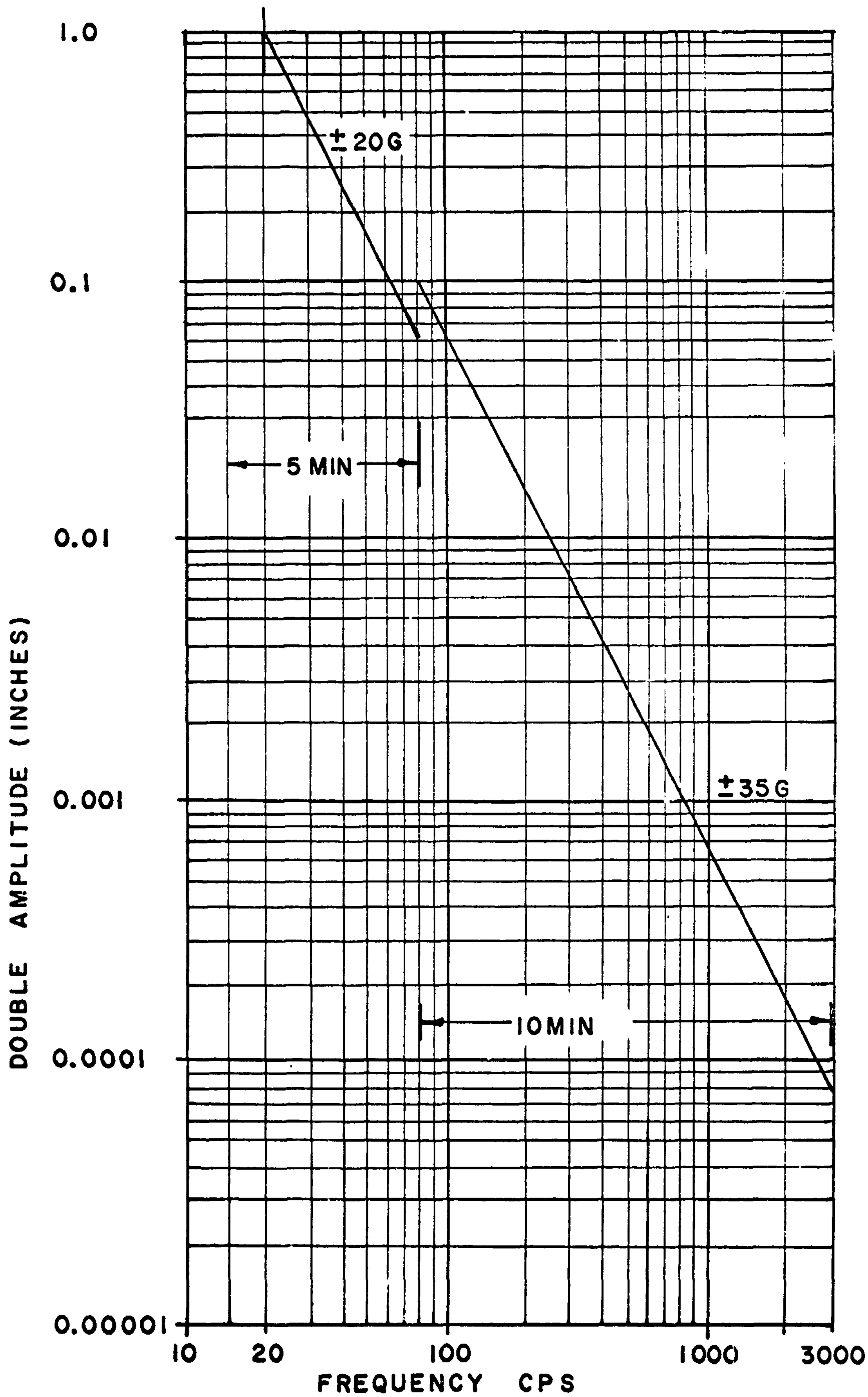
SW_2 = WINDING SELECTOR SWITCH

FIG 8

TEST GROUP		START	DATA TEST POINTS 168 HOUR	500 HOUR	1000 HOUR	1500 HOUR	2000 HOUR
ALL	D3172922	8-16	8-23	9-7	9-27	10-18	11-8
DB	D3172671	8-17	8-24	9-8	9-28	10-19	11-9
COAST	D3172671	8-18	8-25	9-9	9-29	10-20	11-10
RMH	D3172671	8-19	8-26	9-10	9-30	10-21	11-11
MCE	D3172671	8-20	8-27	9-11	10-1	10-22	11-12

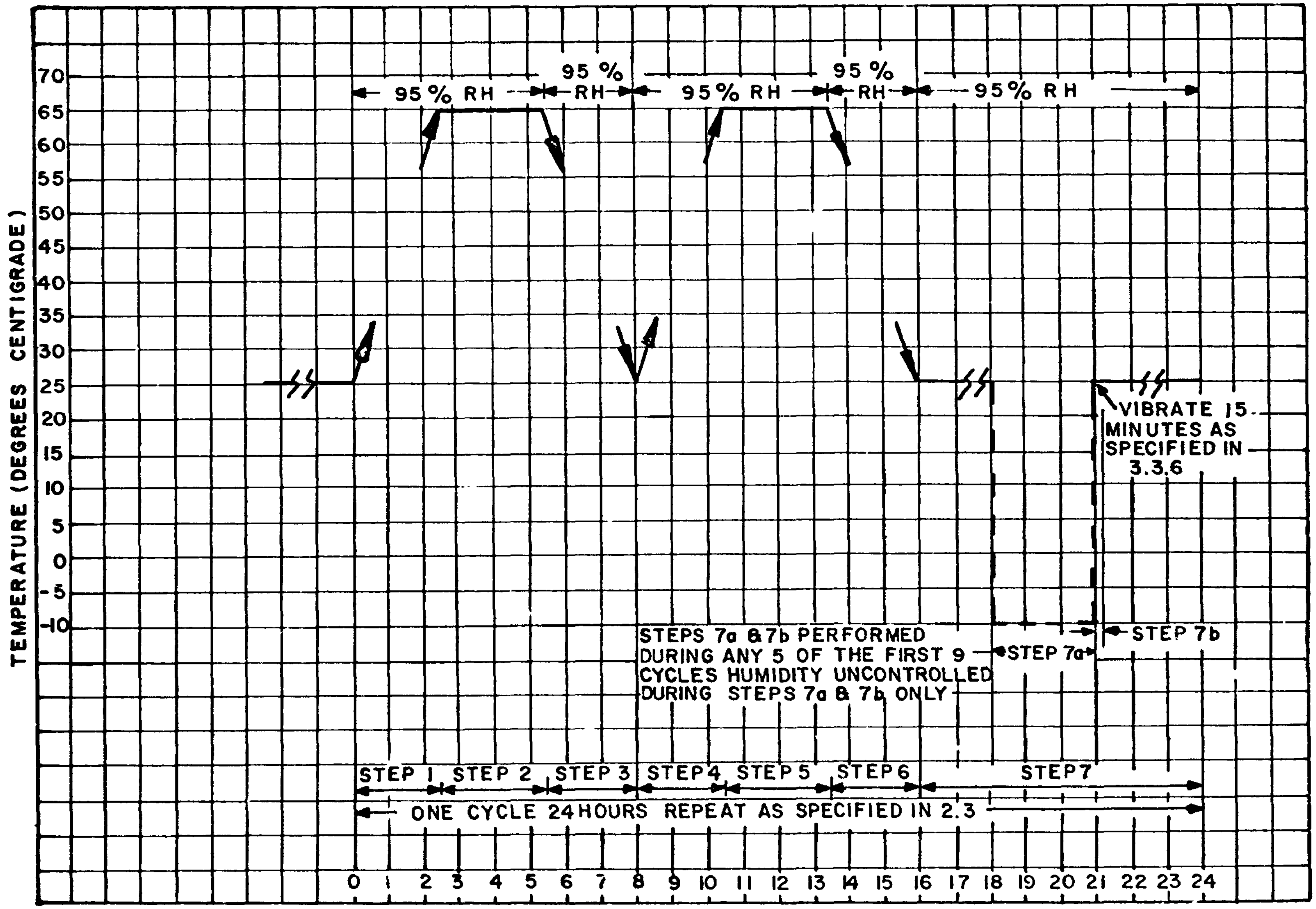
LIFE TEST SCHEDULE

FIG 9



VIBRATION TEST LEVELS

FIG 10


95% RH
95 % RH
95% RH
95 % RH
95% RH
TEMPERATURE (DEGREES CENTIGRADE)
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
VIBRATE 15 MINUTES AS SPECIFIED IN 3.3.6
STEPS 7a & 7b PERFORMED DURING ANY 5 OF THE FIRST 9 CYCLES HUMIDITY UNCONTROLLED DURING STEPS 7a & 7b ONLY
STEP 7a
STEP 7b
STEP 1
STEP 2
STEP 3
STEP 4
STEP 5
STEP 6
STEP 7
ONE CYCLE 24 HOURS REPEAT AS SPECIFIED IN 2.3
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

F NO 729

'AB I

WINDING	TURNS	TURNS RATIO	D C RESISTANCE TERMINAL	OHMS	TOLERANCE	LOAD	
#1 (PRI)	900/900	3.0 ± 1%	BRN – ORN	41.15	± 15 %	NOTE (1)	
#2 (SEC)	300/300	REFERENCE	VIO – BLU	21.05	± 15 %	N/A	

NOTE (1) EXCITATION CURRENT: 24 V RMS 2400 CPS TO PRI (BRN-ORN)
EXCITATION CURRENT .225 ± .2 MA

PART NO. D3172671

WINDING	TURNS	TURNS RATIO ±1%	D C RESISTANCE TERMINAL	OHMS	TOLERANCE	SECONDARY LOAD CURRENTS AMPERES, RESISTIVE LOADS
#1	35/35	.7068	GRN – GRN	0.24	± 15 %	0.44 A
#2	35/35	.7068	BLU – BLU	0.24	± 15%	0.44 A
#3 (PRI)	19/19	.4130	BRN – YEL	0.12	± 15%	– –
#4	36/36	.7826	VIO – VIO	0.28	± 15%	0.30 A
#5	36/36	.7826	GRY – GRY	0.28	± 15%	0.30 A
#6	46/46	REFERENCE	WHT – WHT	1.10	± 15%	0.53 A
#7	46/46	1.0000	W/BLK – W/BLK	1.10	± 15%	0.53 A
#8 (PRI)	19/19	.4130	RED – ORN	0.12	± 15%	– –
#9	27/27	.5869	W/BRN – W/BRN	1.50	± 15 %	0.44 A
#10	12/12	.2608	W/ORN – W/ORN	1.10	± 15 %	– –

TABLE II

CODING INFORMATION

COMPONENT		CODE
Magnetic Circuit Element	D3172671	001
Robert M. Hadley	D3172671	002
D.B. Products	D3172671	003
Coast Coil	D3172671	004
Magnetic Circuit Element	D3172922	005
Robert M. Hadley	D3172922	006
D. B. Products	D3172922	007
Coast Coil	D3172922	008

GROUP CODE	
Group I and III	Unit Serial No.'s 1 thru 4
Group II and IV	Unit Serial No.'s 5 thru 12

TABLE II (Continued)

CODING INFORMATION

PARAMETER	UNIT	DATA COLUMN
D.C.R. Winding #1	Ohm	1
D.C.R. Winding #2	Ohm	2
D.C.R. Winding #3	Ohm	3
D.C.R. Winding #4	Ohm	4
D.C.R. Winding #5	Ohm	5
D.C.R. Winding #6	Ohm	6
D.C.R. Winding #7	Ohm	7
D.C.R. Winding #8	Ohm	8
D.C.R. Winding #9	Ohm	9
D.C.R. Winding #10	Ohm	10
Excitation Current	Milliamperes	1
Ins. Resistance Wdgs. to base	K Megohms	3
Ins. Resistance Pri Wdgs to Sec. Wdgs	K Megohms	4
Diel. Str. Wdgs to Case	Go/No-Go	5
Diel Str Primary Wdgs. to Sec. Wdg.	Go/No-Go	6
Turns Ratio Wdg. #1	Ratio	1
Turns Ratio Wdg. #2	Ratio	2
Turns Ratio Wdg. #3	Ratio	3
Turns Ratio Wdg. #4	Ratio	4
Turns Ratio Wdg. #5	Ratio	5
Turns Ratio Wdg. #6	(Wdg. 6 = 1.000)	6
Turns Ratio Wdg. #7	Ratio	7
Turns Ratio Wdg. #8	Ratio	8
Turns Ratio Wdg. #9	Ratio	9
Turns Ratio Wdg. #10	Ratio	10

TABLE II (Continued)

D3172671		D3172922		
GRP I.	GRP. II	GRP. III	GRP. IV	PLACE IN TEST
01	01	01	01	Initial Electricals
02		02		After Thermal Sterilization
03		03		After Terminal Pull
04	02			After Temperature Rise
05	03	04	02	After Mechanical Shock
06	04	05	03	After Vibration
07	05	06	04	After Moisture Resistance
08	06	07	05	After Temperature Cycling
09	07	08	06	After 168 Hr. Hi Temperature Life
10	08	09	07	After 500 Hr. Hi Temperature Life
11	09	10	08	After 1000 Hr. Hi Temperature Life
12	10	11	09	After 1500 Hr. Hi Temperature Life
13	11	12	10	After 2000 Hr. Hi Temperature Life

TABLE III

PERCENT CATASTROPHIC AND PARAMETRIC FAILURES EACH ENVIRONMENT

POINT IN TEST	COMP. CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Initial	001	12	252	116	46.0	--	--
	002	12	252	---	---	--	--
	003	12	252	38	15.0	1	8.3
	004	12	252	---	---	--	--
	005	12	48	5	11.0	--	--
	006	12	48	3	6.2	--	--
	007	12	48	3	6.2	1	8.3
	008	12	48	---	---	--	--
Post Thermal Sterilization	001	4	84	38	45.2	--	--
	002	4	84	---	---	--	--
	003	4	84	8	9.5	--	--
	004	4	84	---	---	--	--
	005	4	16	4	25.0	--	--
	006	4	16	1	6.2	--	--
	007	4	12	---	---	--	--
	008	4	16	---	---	--	--

TABLE III (Continued)

POINT IN TEST	COMP. CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Post Terminal Pull	001	4	84	34	40.5	--	--
	002	4	84	1	1.2	--	--
	003	4	84	8	9.5	--	--
	004	4	84	---	---	--	--
	005	4	16	3	18.7	--	--
	006	4	16	1	6.2	--	--
	007	3	12	1	8.3	--	--
	008	4	16	---	---	--	--
Post Temperature Rise	001	12	252	107	42.4	--	--
	002	12	252	---	---	--	--
	003	11	231	23	10.0	--	--
	004	12	252	---	---	--	--
Post Mechanical Shock	001	12	252	113	44.8	--	--
	002	12	252	---	---	--	--
	003	11	231	16	6.9	--	--
	004	12	252	---	---	--	--
	005	12	48	8	16.7	--	--
	006	12	48	3	6.2	--	--
	007	11	44	1	2.3	1	9.1
	008	12	48	---	---	--	--

Table III (Continued)

POINT IN TEST	COMP. CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Post Vibration	001	12	252	105	45.4	1	8.3
	002	12	252	3	1.2	--	--
	003	11	231	13	5.6	--	--
	004	12	252	3	1.2	--	--
	005	12	48	5	10.4	--	--
	006	12	48	3	6.2	--	--
	007	10	40	1	2.5	1	10.0
	008	12	48	---	---	--	--
Post Moisture Resistance	001	11	231	105	45.5	--	--
	002	12	252	1	0.4	--	--
	003	11	231	25	10.8	1	9.1
	004	12	252	3	1.2	--	--
	005	12	48	9	18.8	--	--
	006	12	48	6	12.5	2	16.6
	007	9	36	1	2.8	2	22.2
	008	12	48	---	---	--	--

Table III (Continued)

POINT IN TEST	COMP. CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Post Temperature Cycling	001	11	231	104	45.4	--	--
	002	12	252	1	0.4	--	--
	003	10	210	6	2.9	--	--
	004	12	252	2	.8	--	--
	005	12	48	12	25.0	--	--
	006	10	40	1	2.5	3	30.0
	007	7	28	1	3.6	1	14.3
	008	12	48	---	---	--	--
Post 168 Hour Life	001	11	231	71	30.7	--	--
	002	12	252	1	0.4	--	--
	003	10	210	15	7.1	--	--
	004	12	252	3	1.2	--	--
	005	12	48	11	22.9	--	--
	006	7	28	1	3.6	--	--
	007	6	24	2	8.3	--	--
	008	12	48	---	---	--	--

Table III (Continued)

POINT IN TEST	COMP. CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Post 500 Hour Life	001	11	231	87	38.1	--	--
	002	12	252	15	5.9	--	--
	003	10	210	6	2.9	--	--
	004	12	252	3	1.2	--	--
	005	12	48	8	16.7	--	--
	006	7	28	1	3.6	--	--
	007	6	24	1	4.2	--	--
	008	12	48	---	---	--	--
Post 1000 Hour Life	001	11	231	95	41.2	--	--
	002	12	252	1	0.4	--	--
	003	10	210	5	2.4	1	10.0
	004	12	252	3	1.2	--	--
	005	12	48	9	18.5	--	--
	006	7	28	1	3.6	--	--
	007	6	24	1	4.2	--	--
	008	12	48	---	---	--	--

Table III (Continued)

POINT IN TEST	COMP CODE	NO. OF UNITS	TOTAL NO. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
Post 1500 Hour Life	001	11	231	94	41.2	--	--
	002	12	252	12	4.8	--	--
	003	9	189	14	7.4	--	--
	004	12	252	19	7.3	--	--
	005	12	48	9	18.8	--	--
	006	7	28	1	3.6	--	--
	007	6	24	1	4.2	--	--
	008	12	48	---	---	--	--
Post 2000 Hour Life	001	11	231	94	40.7	--	--
	002	12	252	1	0.4	--	--
	003	9	189	21	11.1	--	--
	004	12	252	1	0.4	--	--
	005	12	48	11	22.9	--	--
	006	7	28	1	3.6	--	--
	007	6	24	1	4.2	--	--
	008	12	48	---	---	--	--

TABLE IV

PERCENT CATASTROPHIC AND PARAMETRIC FAILURES
ALL ENVIRONMENTS

COMP. CODE	TOTAL NC. OF PARA. MEASURED	NUMBER OF O.T. FAILURES	% OF O.T. FAILURES	NUMBER OF CATA. FAILURES	% OF CATA. FAILURES
001	2793	1163	41.6	1	8.3
002	2940	36	1.2	-	---
003	2562	198	7.7	3	25.0
004	2940	37	1.2	-	---
005	512	94	18.3	-	---
006	404	23	5.7	5	41.6
007	340	14	4.1	6	50.0
008	512	----	----	-	---

910 Edgewood Place
Denton, Texas 76201
December 20, 1965

John McLin
Varo, Inc.
2201 Walnut Street
Garland, Texas 75041

RE: Purchase Order No. M-54256

Dear Sir:

The following charts, discussion, and recommendations are submitted in regard to the study of J.P.L. Qualification test 902.66-01, in accordance with Para. 3.3.8.4 J.P.L. Specification ZPP-2098-GEN.

It is respectiv[illegible] submitted that all conditions of purchase order Number M-54256 has been met.

Sincerely,

Dr. David R. Cecil
Assistant Professor of Mathematics
North Texas State University

SAMPLE CALCULATION

90% Confidence level for D3172671 Hadley parameter 8, assuming an exponential distribution of failures.

Time	X_i Class Mark	f_i Number of Failures	$X_i f_i$
0 - 168 hr	84 hr	0	0
168 - 500 hr	334 hr	2	668
500 - 1000 hr	750 hr	0	0
1000 - 1500 hr	1250 hr	1	1250
1500 - 2000 hr	1750 hr	0	0
TOTALS		3	1918

$r = 3$

$n = 8$

$T = 1{,}918 + (8 - 3)\ 2000$

$T = 11{,}918$

$2T = 23{,}836$

$\alpha = .10,\quad \frac{\alpha}{2} = .05,\quad 1 - \frac{\alpha}{2} = .95$

$$X^2_{\frac{\alpha}{2}}(2r+2) = X^2_{.05(12)} = 21.03$$

$$X^2_{(1-\frac{\alpha}{2})}(2r) = X^2_{.95(10)} = 3.940$$

$$\frac{X^2_{(1-\frac{\alpha}{2})}(2r)}{2T} < \lambda < \frac{X^2_{\frac{\alpha}{2}}(2r+2)}{2T}$$

λ, Failure rate per hour

$$\frac{3.940}{23{,}836} < \lambda < \frac{21.03}{23{,}836}$$

$$.000166 < \lambda < .000884$$

$$16.6\% < \lambda < 88.4\%$$

λ, Percent failure rate per 1000 hours.

Sample Calculation

Weibull distribution for failure rate.

Part D3172671, Hadley, Parameter 8.

Reading	Internal	Internal Mark	Number of Failures	Cummulative Percent Failure
0	-	--	-	--
168 Hr.	0 - 168	84	0	--
500 Hr.	168 - 500	334	2	25.0%
1000 Hr.	500 - 1000	750	0	--
1500 Hr.	1000 - 1500	1250	3	37.5%
2000 Hr.	1500 - 2000	1750	0	--

For Scale with 1 unit = 100 hours:

y - intercept = - 1.58

$$-\ln\alpha = -1.58$$
$$\alpha = 4.86$$

$$\text{slope} = \frac{-0.20 - (-1.58)}{4.6 - 0.0} = .300$$

$$\hat{\beta} = .300$$

$$g(x) = \frac{.300\ x^{-.613}}{4.86}$$

For scale with 1 unit = 1 hour:

$$t = 100x$$

$$g(t) = \frac{.300t^{-.613}}{(4.86)(3.98)} = 0.0155\ t^{-.613}$$

D3172671

Coast Coil
Parameter 11

84	1	12.5%
334	0	--
750	0	--
1250	1	25.0%

y - intercept = -2.00

$-\ln\alpha = -2.00$

$\alpha = 7.39$

$$\text{slope} = \frac{(-0.7) - (-2.00)}{4.6 - 0.0} = 0.282$$

$$\hat{\delta} = 0.282$$

$$g(x) = \frac{.282\, x^{-.718}}{7.39} \qquad 1 \text{ Unit} = 100 \text{ hrs.}$$

$$g(t) = \frac{.282 t^{-.718}}{(7.39)(2.91)} \qquad 1 \text{ Unit} = 1 \text{ hr.}$$

$$g(t) = 0.0131 \quad t^{-.718}$$

FAILURE REPORT

REPORT NUMBER: 65 | 0019

DATE: MO. [illegible] | DAY [illegible] | YEAR 65

PART NAME: Toroidal Transformer

PART NO. (HST): 001

PART NO. (CUST): 3172671

SERIAL NO.: 004

MANUFACTURER: [illegible]

DATE OF MANUFACTURE: ——

OPER. HRS AT FAILURE: ——

DATE OF FAILURE: 7-17-65

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.): [illegible]lification

TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC): Excitation Current

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ____ °C ③ VIBRATION ____ CPS ⑤ HUMIDITY ____ %

② SHOCK ____ G ④ ALTITUDE ____ PSI ⑥ OTHER ____

REMARKS (DETAILS CONCERNING FAILURE)

Unit failed electrical test following vibration. Windings #3 & [illegible] shorted together.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR: [signature]

DEPT: [illegible] Env. Lab

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK): ① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE: Primary Windings Shorted Together

CAUSE OF FAILURE: [illegible] windings were wound such that the windings [illegible] within the toroid. Examination revealed the wire [illegible] had [illegible] at this point.

FAILURE CLASSIFICATION (CHECK): ☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION: ☐ DESIGN ☐ Q.C. ☐ MFG.

DATE ACTION WILL BE INITIATED:

DEPT AUTH (INITIALS)

CORRECTIVE ACTION EFFECTIVE ON: RUN ____ LOT ____ BATCH ____ SERIAL NUMBER ____

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0020

DATE MO.	DAY	YEAR
[illegible]	1	65

PART NAME	PART NO. (NST)	PART NO. (CUST)	SERIAL NO.
Toroidal [illegible]	003	317[illegible]671	004

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible] Products	———	———	August 11, 1965

TEST TYPE (QUAL. – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
[illegible]ification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ g ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

Unit failed electrical test following moisture resistance. Insulation breakdown [illegible] between windings.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR: R. W[illegible]

DEPT 4[illegible]-5 Env. Lab

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK)	MODE OF FAILURE
① MECH. ___ ② ELECT X ③ OPER ___	Insulation breakdown

CAUSE OF FAILURE

Break in insulation between two adjacent leads of windings 9 & 10

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0021

DATE MO.	DAY	YEAR
(	9	65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	003	3172671	012

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
D.B. Products	----------	------------	9-28-65

TEST TYPE (QUAL. – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
Qualification	D.C. Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

(1) TEMP ________ °C (3) VIBRATION ________ CPS (5) HUMIDITY ________ %

(2) SHOCK ________ G (4) ALTITUDE ________ PSI (6) OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

Post 1000 Hour Life DCR Measurement indicated winding #9 open circuited.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR: RW

DEPT: Env. Lab 425-5

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK)	MODE OF FAILURE
(1) MECH. ___ (2) ELECT ___ (3) OPER ___	Open Winding

CAUSE OF FAILURE: One of the leads was too brittle - broke very easily. Could not determine exact point of open circuit.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT. RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

INSTRUCTIONS:

(1) USE SOFT PENCIL OR BLACK BALL POINT.

(2) USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0021

DATE MO.	DAY	YEAR
9	1	65

PART NAME	PART NO.(HST)	PART NO.(CUST)	SERIAL NO.
Toroidal Transformer	003	3172671	007

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible] Products	-------	-------	4-[illegible]-65

TEST TYPE (QUAL.- ACPT.- INSP.- ETC.)	TEST CONDITIONS (SHOCK — D.C.R.— HI-POT—ETC)
Qualification	D.C. Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ G ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

Winding #4 of unit showed open circuit - Initial Electrical Test

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY—
RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR R. W[illegible]

DEPT 4[illegible]-5 Env. Lab

FAILURE ANALYSIS

DATE		
11	20	65

FAILURE TYPE (CHECK) ① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE Open circuit

CAUSE OF FAILURE "Cold solder joint" at termination of winding and lead wire.

FAILURE CLASSIFICATION (CHECK)
☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION ☐ DESIGN ☐ Q.C. ☐ MFG.	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)

CORRECTIVE ACTION EFFECTIVE ON:
RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #255

FAILURE REPORT

REPORT NUMBER	
5	[illegible]32

DATE MO.	DAY	YEAR
[illegible]	[illegible]	[illegible]

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	007	[illegible]17[illegible]	[illegible]5

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible] Products	———	———	[illegible], 1965

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.)	TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC)
Qualification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

[illegible] Moisture Resistance measurement indicated insulation breakdown [illegible] windings to core.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR	DEPT
R. W[illegible]	[illegible]-5 Env. Lab

FAILURE ANALYSIS

DATE		
11	20	65

FAILURE TYPE (CHECK)	MODE OF FAILURE
① MECH. ___ ② ELECT X ③ OPER ___	Insulation breakdown

CAUSE OF FAILURE

Break in insulation [illegible] of secondary windings.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
[illegible]5	[illegible]

DATE MO.	DAY	YEAR
[illegible]	1	[illegible]

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
[illegible]	[illegible]7	[illegible]	[illegible]07

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible]	———	———	August 11, 1965

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.)	TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC)
[illegible]ification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

Initial [illegible] insulation breakdown - windings to case.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR: R. W[illegible]

DEPT: [illegible]5-5 Env. Lab

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK)	MODE OF FAILURE
① MECH. ___ ② ELECT [illegible] ③ OPER ___	Insulation breakdown

CAUSE OF FAILURE [illegible] both primary and secondary windings.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER: 5 | 00[illegible]

DATE: MO. [illegible] | DAY [illegible] | YEAR [illegible]

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroi[illegible] [illegible]former	007	[illegible]	00[illegible]

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible]	———	———	[illegible]

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.)	TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC)
[illegible]	Insul[illegible]

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

[illegible] electric[illegible] breakdown [illegible] to [illegible].

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR: R. W[illegible]

DEPT 425-5 [illegible]

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK): ① MECH. ___ ② ELECT X ③ OPER ___

MODE OF FAILURE: Insul[illegible] [illegible]down

CAUSE OF FAILURE

[illegible] (Ho[illegible]) [illegible] secondary [illegible].

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER: [illegible]5 | [illegible]5

DATE: MO. [illegible] | DAY [illegible] | YEAR 65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
[illegible]	[illegible]7	[illegible]	009

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible]	————	————	[illegible]

TEST TYPE (QUAL, – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
[illegible]	Insul[illegible]tion [illegible]esist[illegible]nce

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ G ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

[illegible] breakdown,

[illegible]

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR: R. W[illegible]

DEPT: [illegible]-5 Env. L[illegible]b

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK): ① MECH. ____ ② ELECT ____ ③ OPER ____

MODE OF FAILURE: Insul[illegible]tion [illegible]

CAUSE OF FAILURE: [illegible]

[illegible] during shock.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

REPORT NUMBER [illegible]

FAILURE REPORT

DATE MO. [illegible] | DAY [illegible] | YEAR [illegible]

PART NAME Toroidal Transformer

PART NO. (HST) [illegible]07

PART NO. (CUST) [illegible]

SERIAL NO. [illegible]

MANUFACTURER D.F. Products

DATE OF MANUFACTURE ———

OPER. HRS AT FAILURE ———

DATE OF FAILURE

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.) [illegible]

TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC) Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

Post Moisture Resistance Measurement indicated insulation [illegible] lines to case.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR R. W[illegible]

DEPT [illegible] [illegible]

FAILURE ANALYSIS

DATE 11 | 20 | 65

FAILURE TYPE (CHECK)

① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE Insulation Breakdown

CAUSE OF FAILURE Crack in insulation [illegible] during winding.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION ☐ DESIGN ☐ Q.C. ☐ MFG.

DATE ACTION WILL BE INITIATED:

DEPT AUTH. (INITIALS)

CORRECTIVE ACTION EFFECTIVE ON;

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
[illegible]5	0027

DATE MO.	DAY	YEAR
[illegible]	[illegible]	[illegible]5

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
[illegible]	[illegible]7	3172[illegible]	011

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
[illegible]	------	-------	8-11-65

TEST TYPE (QUAL. – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
[illegible]	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ____ °C ③ VIBRATION ____ CPS ⑤ HUMIDITY ____ %

② SHOCK ____ G ④ ALTITUDE ____ PSI ⑥ OTHER ____

REMARKS (DETAILS CONCERNING FAILURE)

[illegible] Indicated insulation breakdown – [illegible] to case.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR: [illegible]

DEPT: 4[illegible]-5 Env. Lab.

FAILURE ANALYSIS

DATE: 11 | 19 | 65

FAILURE TYPE (CHECK)

① MECH. ____ ② ELECT ____ ③ OPER ____

MODE OF FAILURE: Insul[illegible]tion Bre[illegible]down

CAUSE OF FAILURE: [illegible].

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ____ LOT ____ BATCH ____ SERIAL NUMBER ____

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0078

DATE MO.	DAY	YEAR
[illegible]	1	65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	006	317 922	001

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
Hadley	---- -------	------------	2-11-65

TEST TYPE (QUAL. — ACPT. — INSP. — ETC.)	TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC.)
Qualification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

Post Moisture Resistance Measurement indicated Insulation Breakdown - Primary to secondary

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR	DEPT
R. W[illegible]	425-5 Env. Lab

FAILURE ANALYSIS

DATE		
11	22	65

FAILURE TYPE (CHECK) ① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE: Insulation Breakdown

CAUSE OF FAILURE: Insufficient thickness of insulating tape at termination of secondary.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT. RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0029

DATE MO.	DAY	YEAR
9	1	65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	006	3172[illegible]	002

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
H[illegible]	----	--------	8-11-65

TEST TYPE (QUAL. – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
[illegible]lification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ G ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

[illegible] Resistance Measurement indicated insulation breakdown - Primary to secondary.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR R. W[illegible]

DEPT 425-5 Env. Lab

FAILURE ANALYSIS

DATE		
11	21	65

FAILURE TYPE (CHECK)

① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE

Insulation Breakdown

CAUSE OF FAILURE

Break in insulation [illegible] between windings.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

IN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0030

DATE MO.	DAY	YEAR
8	1	65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	006	317922	004

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
Hadley	----------	----------	8-11-65

TEST TYPE (QUAL. – ACPT. – INSP. – ETC)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
Qualification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ FT ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

Post Moisture Resistance Measurement indicated Insulation Breakdown - Secondary to case.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR: R. W. [illegible]

DEPT 445-5 E. V. Lab

FAILURE ANALYSIS

DATE: 11 | 20 | 65

FAILURE TYPE (CHECK)	MODE OF FAILURE
① MECH. ___ ② ELECT X ③ OPER ___	Insulation Breakdown

CAUSE OF FAILURE

Break in insulation of one of the secondary leads. Insulation [illegible] came off at [illegible] of secondary termination (Wrapping).

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

FORM #235

FAILURE REPORT

REPORT NUMBER	
65	0031

DATE MO.	DAY	YEAR
9	1	65

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	006	3172922	009

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
Hadley	————	————	8-11-65

TEST TYPE (QUAL. – ACPT. – INSP. – ETC.)	TEST CONDITIONS (SHOCK – D.C.R. – HI-POT – ETC)
Qualification	Insulation Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP. ______ °C ③ VIBRATION ______ CPS ⑤ HUMIDITY ______ %

② SHOCK ______ G ④ ALTITUDE ______ PSI ⑥ OTHER ______

REMARKS (DETAILS CONCERNING FAILURE)

Post Moisture Resistance measurement indicated insulation breakdown between windings

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY – RETAIN SECOND COPY – SEND LAST COPY WITH PART.

ORIGINATOR R. W. ———

DEPT 4 5-5 Env. Lab.

FAILURE ANALYSIS

DATE 11 | 28 | 65

FAILURE TYPE (CHECK)	MODE OF FAILURE
① MECH. ____ ② ELECT X ③ OPER ____	Insulation breakdown

CAUSE OF FAILURE

Break in insulating tape between windings.

FAILURE CLASSIFICATION (CHECK)

☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

CORRECTIVE ACTION EFFECTIVE ON:

RUN ______ LOT ______ BATCH ______ SERIAL NUMBER ______

REFERENCES:

INSTRUCTIONS:

① USE SOFT PENCIL OR BLACK BALL POINT.

② USE SEPARATE REPORT FOR EACH PART.

FORM #235

REPORT NUMBER	
65	003[illegible]

DATE MO.	DAY	YEAR
9	1	65

FAILURE REPORT

PART NAME	PART NO. (HST)	PART NO. (CUST)	SERIAL NO.
Toroidal Transformer	006	3172922	012

MANUFACTURER	DATE OF MANUFACTURE	OPER. HRS AT FAILURE	DATE OF FAILURE
Hadley	————	————	[illegible]-11-65

TEST TYPE (QUAL, — ACPT. — INSP. — ETC.)	TEST CONDITIONS (SHOCK — D.C.R. — HI-POT — ETC)
Qualification	D.C. Resistance

ENVIRONMENTAL CONDITIONS AT FAILURE

① TEMP ________ °C ③ VIBRATION ________ CPS ⑤ HUMIDITY ________ %

② SHOCK ________ G ④ ALTITUDE ________ PSI ⑥ OTHER ________

REMARKS (DETAILS CONCERNING FAILURE)

Post Moisture Resistance Measurement indicated an open circuited secondary winding.

ROUTE VELLUM (FIRST SHEET) TO RELIABILITY — RETAIN SECOND COPY — SEND LAST COPY WITH PART.

ORIGINATOR: R. W. —

DEPT: 4 5-5 Env. Lab

FAILURE ANALYSIS

DATE: 11 | 19 | 65

FAILURE TYPE (CHECK): ① MECH. ____ ② ELECT X ③ OPER ____

MODE OF FAILURE: Secondary Winding Open

CAUSE OF FAILURE: Dissection revealed a "Dent" in the secondary winding (outer extremity of wound toroid) which was evidently caused by a sharp object during the winding process. At this point the wire was nicked and finally opened.

FAILURE CLASSIFICATION (CHECK): ☐ DESIGN ☐ NONCONFORMANCE TO DESIGN

CORRECTIVE ACTION NECESSARY

RELIABILITY DEPT. REP.

DEPT. RESP. FOR ACTION	DATE ACTION WILL BE INITIATED:	DEPT. AUTH. (INITIALS)
☐ DESIGN ☐ Q.C. ☐ MFG.		

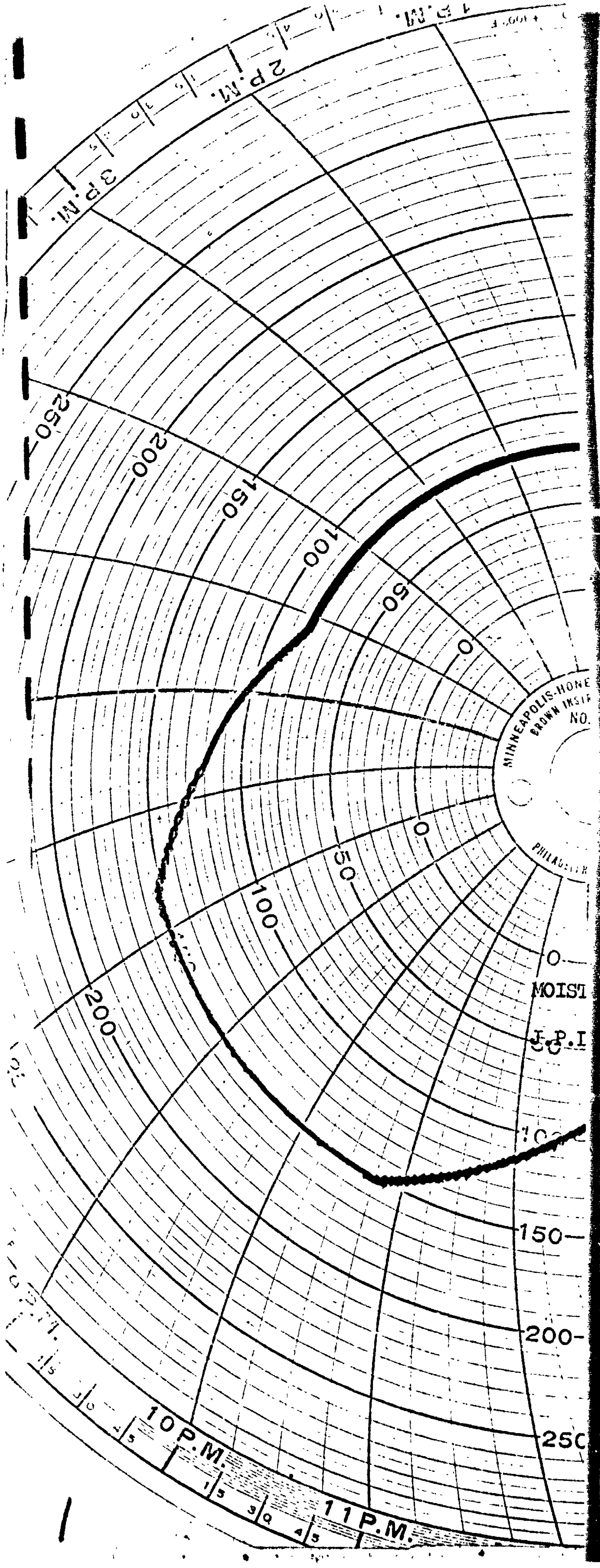
CORRECTIVE ACTION EFFECTIVE ON:

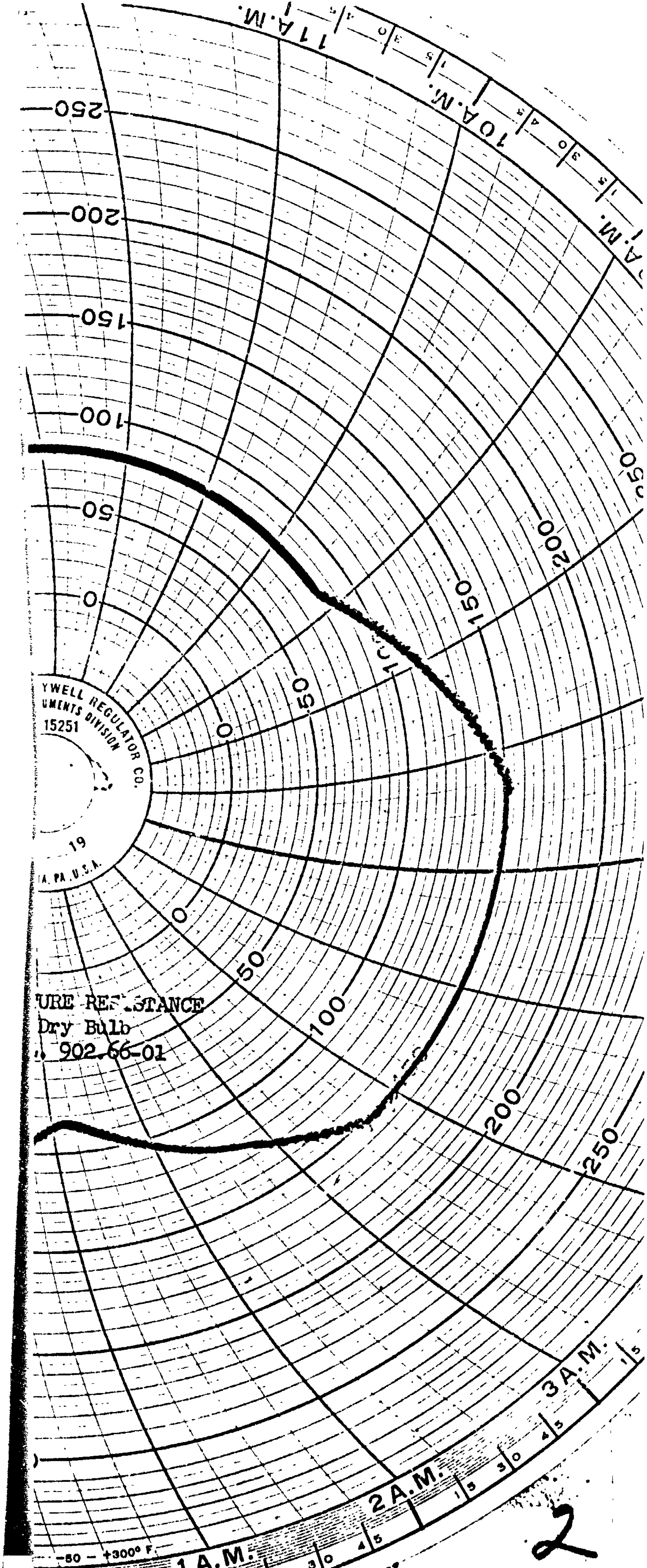
RUN ________ LOT ________ BATCH ________ SERIAL NUMBER ________

REFERENCES:

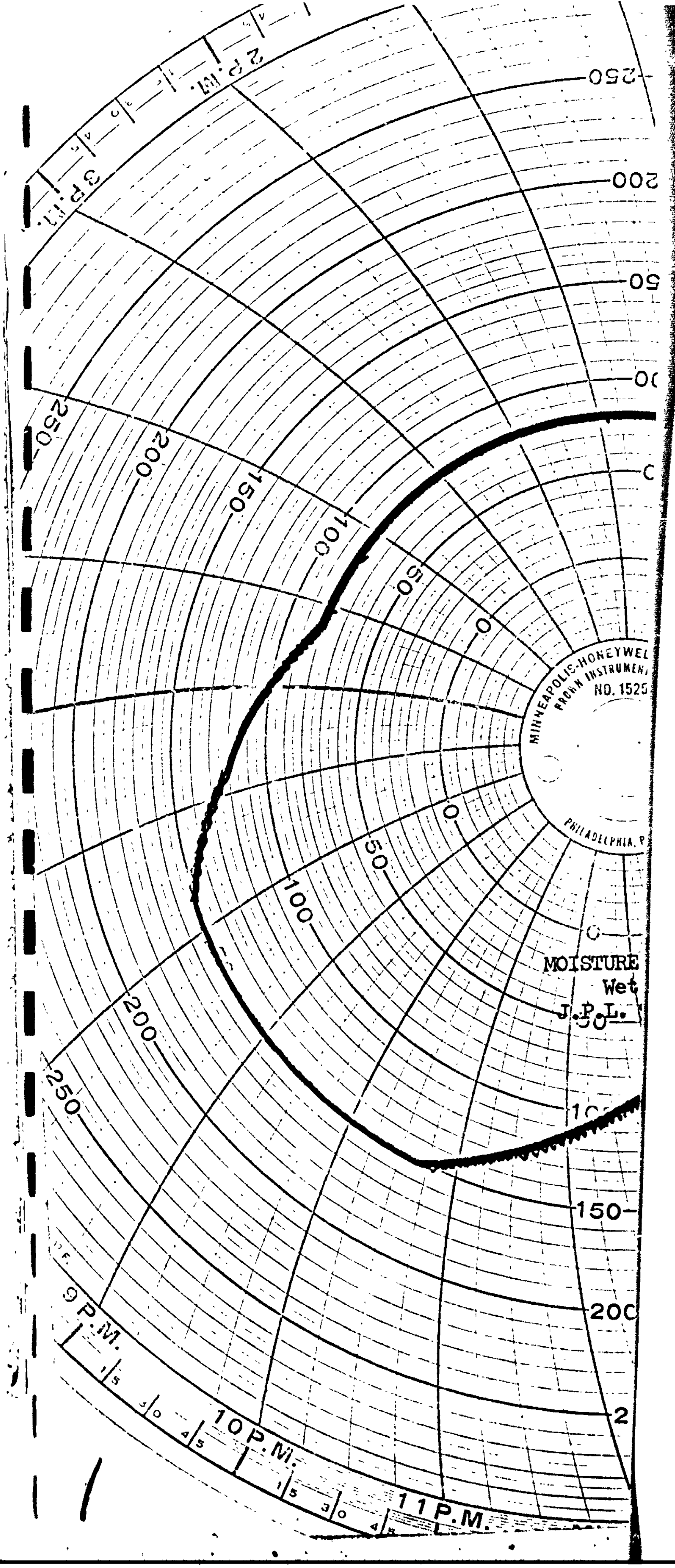
INSTRUCTIONS:
① USE SOFT PENCIL OR BLACK BALL POINT.
② USE SEPARATE REPORT FOR EACH PART.

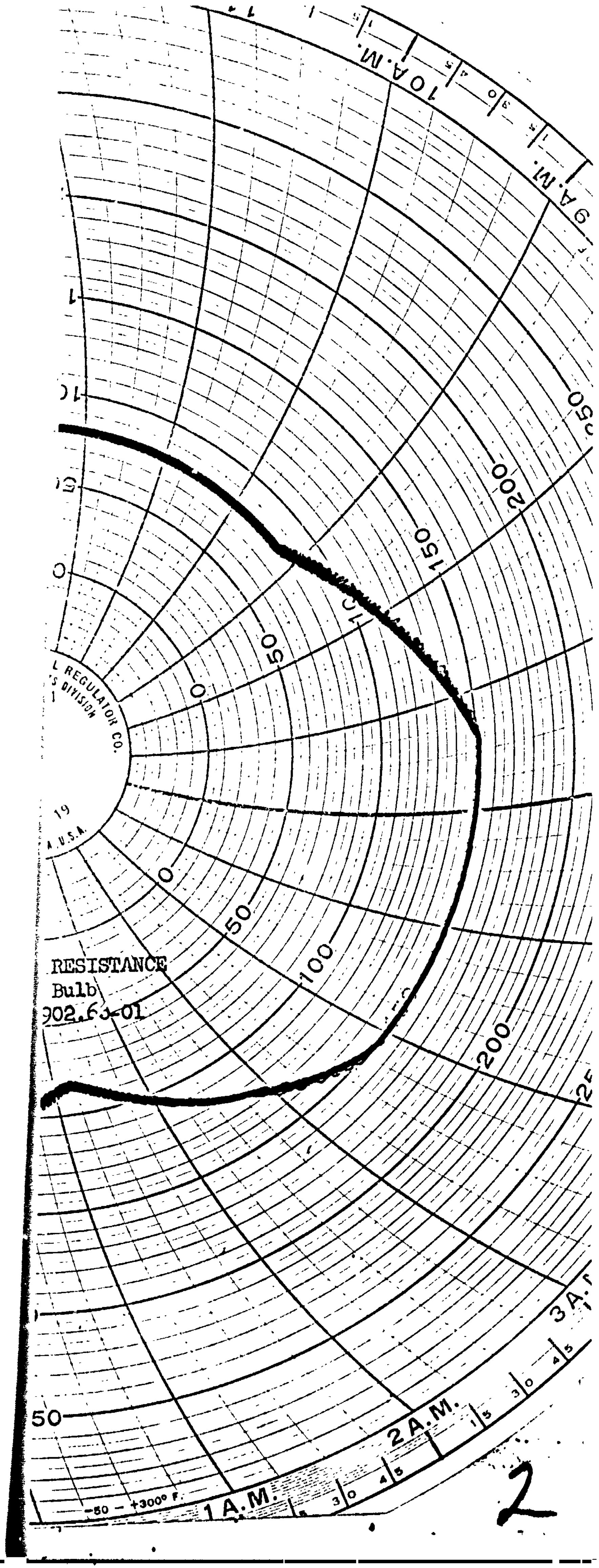
FORM #235


2 P.M.
3 P.M.
10 P.M.
11 P.M.
250
200
150
100
50
0
MOIST
J.P.I
PHILADELPHIA

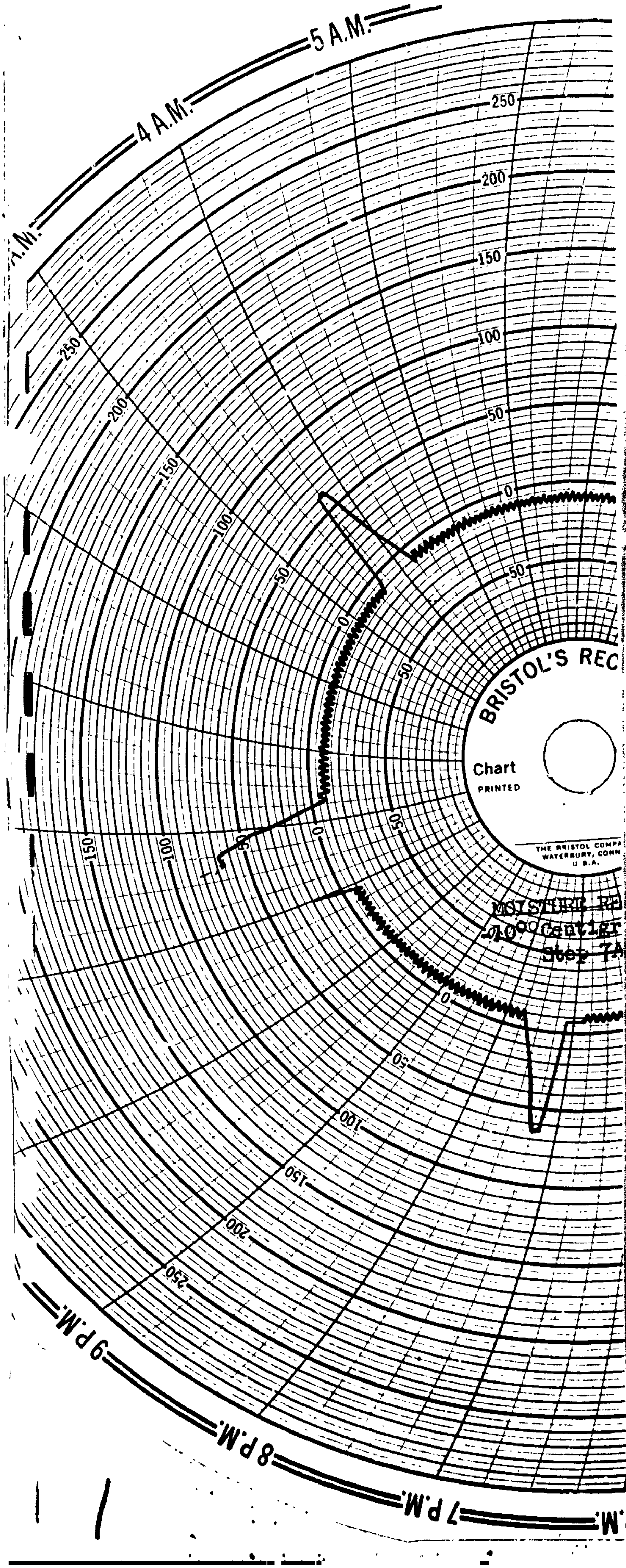

11 A.M.
10 A.M.
250
200
150
100
50
0
YWELL REGULATOR CO.
UMENTS DIVISION
15251
19
A. PA. U.S.A.
Dry Bulb
902.66-01
1 A.M.
2 A.M.
3 A.M.
-50 — +300° F

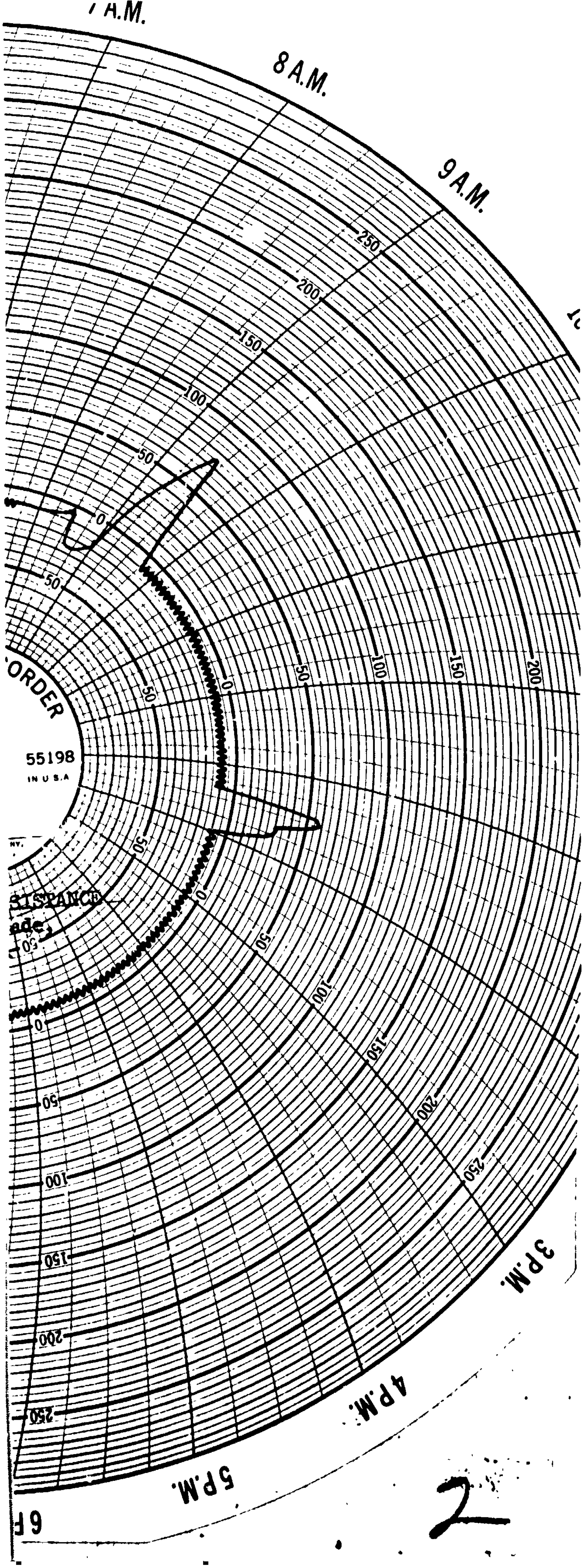
2


MINNEAPOLIS-HONEYWELL
BROWN INSTRUMENT
NO. 1525
PHILADELPHIA, P
MOISTURE
Wet
J.P.L.
9 P.M.
10 P.M.
11 P.M.
2 P.M.
3 P.M.
250
200
150
100
50
0


10 A.M.
9 A.M.
3 A.
2 A.M.
1 A.M.
REGULATOR CO.
DIVISION
19
U.S.A.
RESISTANCE
Bulb
-50 — +300° F.
0
50
100
150
200

2


5 A.M.
4 A.M.
BRISTOL'S REC
Chart
PRINTED
THE BRISTOL COMPA
WATERBURY, CONN
U.S.A.
MOISTURE RE
10° Centigr
Step 7A
9 P.M.
8 P.M.
7 P.M.



2